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Potential Output : Measurement Methods, "New" Economy Influences and Scenarios for 2001-2010 - A Comparison of the EU15 and the US -

by

Kieran Mc Morrow and Werner Roeger*

* The authors are economists in the Directorate-General for Economic and Financial Affairs (ECFIN) of the European Commission.

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INTRODUCTORY REMARKS

Any meaningful analysis of cyclical developments, of medium term growth prospects or of the stance of fiscal and monetary policies are all predicated on either an implicit or explicit assumption concerning the rate of potential output growth. Such pervasive usage in the policy arena is hardly surprising since potential output constitutes the best composite indicator of the aggregate supply side capacity of an economy and of its scope for sustainable, non-inflationary, growth. The concept not only provides a summary indication of the underlying health or relative performance of an economy at a given point in time but can also be used for policy assessments over longer periods, by, for example, providing a reference value for judging the effectiveness of specific or general, economy-wide, microeconomic reform initiatives.

Over recent years, this concept of potential growth has been receiving even more attention than normal in European policy making circles due to both the ongoing "new" economy debate as well as the launching of the Lisbon structural reform process. Regarding "new" economy influences and the respective importance of these effects in both the EU and the US economies, the accepted wisdom, at least up until recently, was that the rapid acceleration in the productivity performance of the ICT sector in the second half of the 1990's would continue on for the foreseeable future, bringing with it the strong possibility of a permanent upturn in trend growth. While central elements of this thesis are now being seriously questioned, it is still nevertheless clear that at least part of the ICT story is likely to persist over the coming years. Turning to the policy front, the EU is currently embarking on an ambitious programme of supply side reforms which, if successfully implemented, will impact strongly on all aspects of the EU's underlying growth determinants. This efficiency drive in the EU over the coming decade is of course inextricably linked with the "new" economy theme since it is an attempt to enable Europe to fully exploit the opportunities which are coming on stream due to the acceleration in the pace of technical change.

Against the above background of a high degree of uncertainty, at the present time, over both the long term impact of the ICT "revolution" and the degree of enthusiasm with which EU governments will implement their ambitious reform agenda, it is important to look again at the concept of potential growth in terms of both the methodological measurement issues and also with regard to putting some numbers on the future outlook for both the EU and US economies over the next 10 years. This paper tries to bring all the various strands together to form a comprehensive piece of research on potential growth, including describing the various statistical and economic methods which are commonly used to calculate the concept; by making an objective and detailed assessment of potential output developments in recent years, including "new" economy effects, and comparing it with the experience of previous decades; and, finally, by using the preceding analysis to provide an evaluation of likely future trends in the area of potential growth in both the EU and the US based on a clear set of operating assumptions.

THE CONCEPT OF POTENTIAL OUTPUT: Given the importance of the potential output concept, it is hardly surprising that its measurement is the subject of contentious and

sustained research interest. Of course since potential output is an unobserved variable, before starting to measure it one must firstly clarify exactly what one means by the concept. This concept signifies different things to different people, especially when discussed over various time horizons, with the concept appreciated differently when placed in a short, medium or long term perspective :

- In the **short run** (i.e. less than one year), the physical productive capacity of an economy may be regarded as being quasi fixed and its comparison with the effective / actual output developments (i.e. in output gap analysis) shows by how much total demand can develop during that short period without inducing supply constraints and inflationary pressures.
- In the **medium term** (i.e. over the next five years), the expansion of domestic demand when it is supported by a strong upturn in the amount of productive investment may endogenously generate the productive output capacity needed for its own support. The latter is all the more likely to occur when profitability is high and either increased or supported by an adequate wage evolution with respect to labour productivity.
- Finally, in the **long run** (i.e. 10 years and beyond) the notion of full employment potential output is linked more to the future evolution of technical progress (or total factor productivity) and to the likely growth rate of labour potential. For the latter, the EU is paradoxically in a much better position than the US, thanks to its present very low employment rate (with respect to the population of working age) and its very high rates of structural and cyclical unemployment (as a proportion of the active population).

These medium and long run considerations should always be kept in mind when discussing potential output since the latter is often seen in an excessively static manner in some policy making fora, where the growth of capacity is often presented as invariant not only in the short run (where such an assumption is warranted) but also over the medium term as if the projection of fixed investment had no impact on productive capacity. Similarly, the growth potential contained in the EU's labour reserve is not often perceived as such. Finally, since a high potential growth rate is an absolute pre-condition for the achievement of a strong and sustainable effective growth path and since this development of the output potential is undoubtedly affected by economic policies, the concept of potential growth has consequently an important role to play in the definition of short, medium and long run policy strategies at the national and international levels.

**GENERAL CONSIDERATIONS CONCERNING THE CHOICE BETWEEN A STATISTICAL V
AN ECONOMIC ESTIMATION METHOD FOR CALCULATING POTENTIAL OUTPUT:**

Notwithstanding the importance of the concept, and the consequent desire for clarity, the measurement of potential growth is far from straightforward and, being unobservable, can only be derived from either a purely statistical approach (which may suffice for short run purposes) or from a full econometric analysis (more appropriate for medium and long run studies). It is clear however that conducting such analysis requires a number of arbitrary choices, either at the level of parameters (in statistical methods) or in the theoretical approach and choice of specifications, data and techniques of estimation (in econometric work). In other words, all the available methods have "pros" and "cons" and none can unequivocally be declared better than the alternatives in all cases. Thus, what matters is to have a method

adapted to the problem under analysis, with well defined limits and, in international comparisons, one that deals identically with all countries.

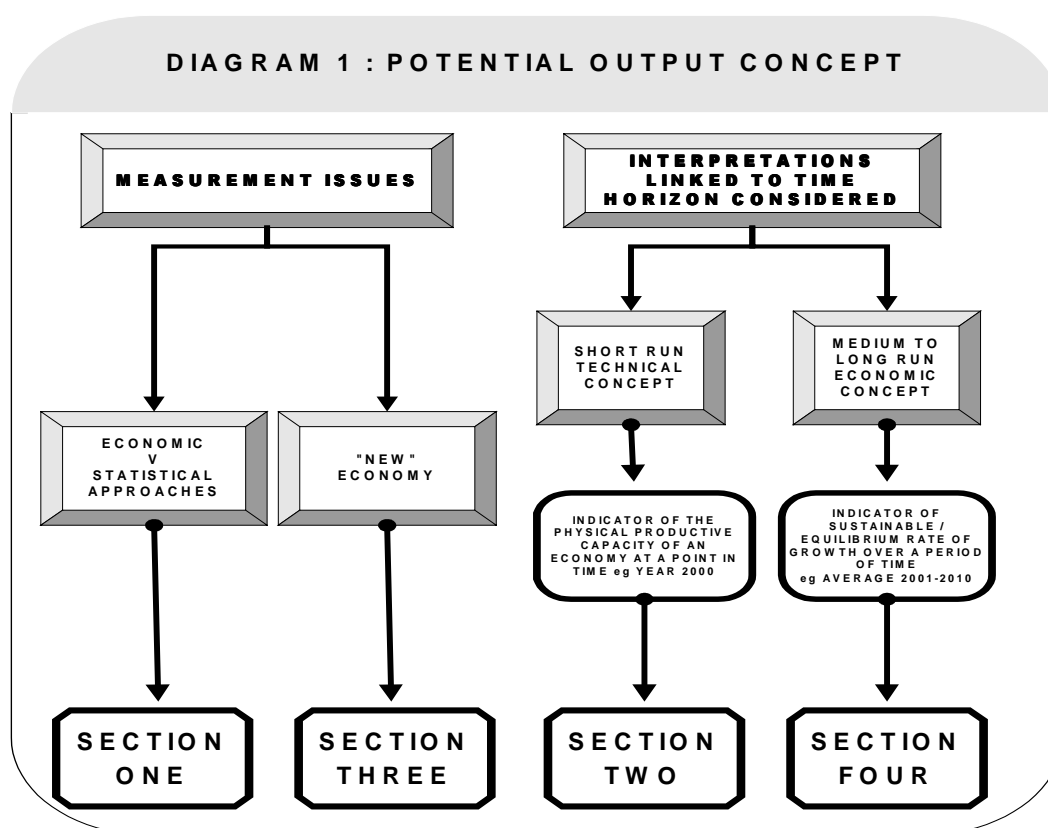
Given the methodological choices outlined in the previous paragraph, the essential question to be addressed in terms of calculating potential output is whether an economic, as opposed to a statistically based, approach provides the best way to proceed. Clearly, for the purposes of any continuous monitoring exercise, statistical trend estimation methods have a number of important advantages, including conceptual simplicity, ease of construction, relatively timely in terms of availability and finally a minimum of value judgements to be used. However, as against these latter gains one perhaps loses the possibility of examining the underlying economic factors which are driving any observed changes in the potential output indicator or indeed the opportunity of establishing any meaningful link between policy reform measures with actual outcomes. In the same way, whilst economic estimation¹ would appear to overcome, at least partially, the latter concerns in terms of appraising policy effectiveness, on the negative side difficulties clearly emerge in terms of achieving a consensus amongst policy makers on the modelling and estimation methods to be employed. Policy makers need to be made fully aware of these latter trade-offs which make any decision making process, involving a choice between the statistical and economic approaches to calculating potential / trend output², a difficult one to undertake in practice.

LARGE EMPHASIS ON THE MEASUREMENT OF TREND PRODUCTIVITY : An important message from growth theory and growth empirics is the crucial role played by technical progress in the growth process. This paper consequently devotes a large amount of attention to the measurement of trend productivity. Indeed, growth accounting exercises typically attribute not more than 50% of output growth to capital and labour. There is generally a large residual, also known as “Total Factor Productivity” (TFP), the evolution of which is especially important to examine when analysing the medium to long term prospects of an economy. This seems particularly relevant for current policy discussions in the light of “new” economy developments (see Section 3). Unfortunately there is an abundance of theories explaining TFP trends. Most hypotheses postulate a link between tangible and intangible capital formation and technical progress. While our knowledge about the driving forces of technical progress will necessarily be limited, nevertheless theory provides some guidance in this area which can conceivably be used for potential output estimation. This proves useful in determining the exact features of the “vintage” TFP extraction method which is favoured in the present paper.

¹ One of the advantages of using an economic estimation method is that it is capable of highlighting the close relationship between the potential output and NAIRU concepts, given that the production function approach to calculating potential output requires estimates to be provided of “normal” or equilibrium rates of unemployment. At a wider level, another advantage of economic theory based methods is the possibility of making forecasts, or at least building scenarios, of possible future growth prospects by making explicit assumptions on the future evolution of demographic, institutional and technological trends. This possibility is fully exploited in section 4 of the present paper.

² In order to avoid the continuous use of the terms potential / trend output, this study adopts the former term as the “default” unless a clear distinction is needed between the statistical (i.e. trend) and economic (i.e. potential) concepts. As will be made clear in section 1, trend GDP corresponds to the mean value of GDP over the cycle i.e. the level of output under an average utilisation of production factors. Potential GDP, on the other hand, is defined as the level of output which can be produced without creating inflationary tensions i.e. with full utilisation of the existing capital stock, a level of employment consistent with non-accelerating wage inflation and a normal (i.e. trend) level of efficiency of factor inputs. In terms of the production possibility frontier concept, the potential output measure produced does not therefore constitute a maximum but is, in fact, closer to the concept of a mean or average production level which underlies the trend output concept.

CONTENTS OF PAPER : This paper is divided into four sections. Section 1 deals with measurement issues and provides an overview of both the main statistical trend estimation methods as well as the more economically respectable production function approach. Section 2 gives a detailed presentation of the potential output and output gap figures for the EU15 and the US using both the preferred statistical method, namely the HP filter, as well as the production function (PF). It also assesses whether the vintage method of extracting the trend TFP component in the PF approach suffers from a procyclical bias and whether the inclusion of a capacity utilisation indicator in the estimation equation could remedy this "bias". The last two sections of the paper assess the plausibility of the, production function derived, potential growth estimates for the EU and the US for recent years and ask the question whether these growth estimates are sustainable over the long run. More specifically, section 3 provides an assessment concerning the evidence in terms of "new" economy influences on growth in both geographical areas using both a static, growth accounting, analysis and simulations using a dynamic general equilibrium model. Finally, section 4 provides some illustrative scenarios for the EU and US economies over the next decade based on alternative assumptions regarding the working age population, the NAIRU, the speed of technical change and investment patterns.



SECTION 1
MEASUREMENT OF POTENTIAL OUTPUT :
STATISTICAL V ECONOMIC APPROACHES

OVERVIEW OF METHODS : All trend estimation procedures, be they economic or statistical, to decompose a macroeconomic time series into trend and cycle suffer from the fact that neither component is directly observable, which makes it difficult to assess the quality of any resultant trend estimates. To overcome this lack of observability, the decomposition process is normally achieved by making a number of identifying assumptions on the functional form and stochastic properties of the trend component and on the relationship / correlation between the trend and the cycle. Besides certain technical differences relating to the estimation procedures, alternative methods differ mainly concerning these identifying assumptions. Two general approaches can be distinguished:

- statistical approaches used widely in time series analysis which are described in section 1.1 and evaluated in section 1.2 (i.e. Hodrick-Prescott filter, band pass filter, deterministic trend method, unobserved components / Kalman Filtering modelling, Beveridge Nelson methods and the Blanchard and Quah decomposition); and
- an economic theory-based approach i.e. the production function method. This latter method is an alternative way of extracting a cyclical component from the data by making assumptions on the functional form of the production technology, returns to scale, the trend growth of technical progress as well as on the 'average' utilization rate of production factors, including an estimate of the trend employment and unemployment rates. Though the production function approach is an attractive method for calculating trend / potential output, the problem of trend elimination from GDP or production output is in a sense shifted to calculating trend values of production inputs. This economic approach is described in section 1.3.

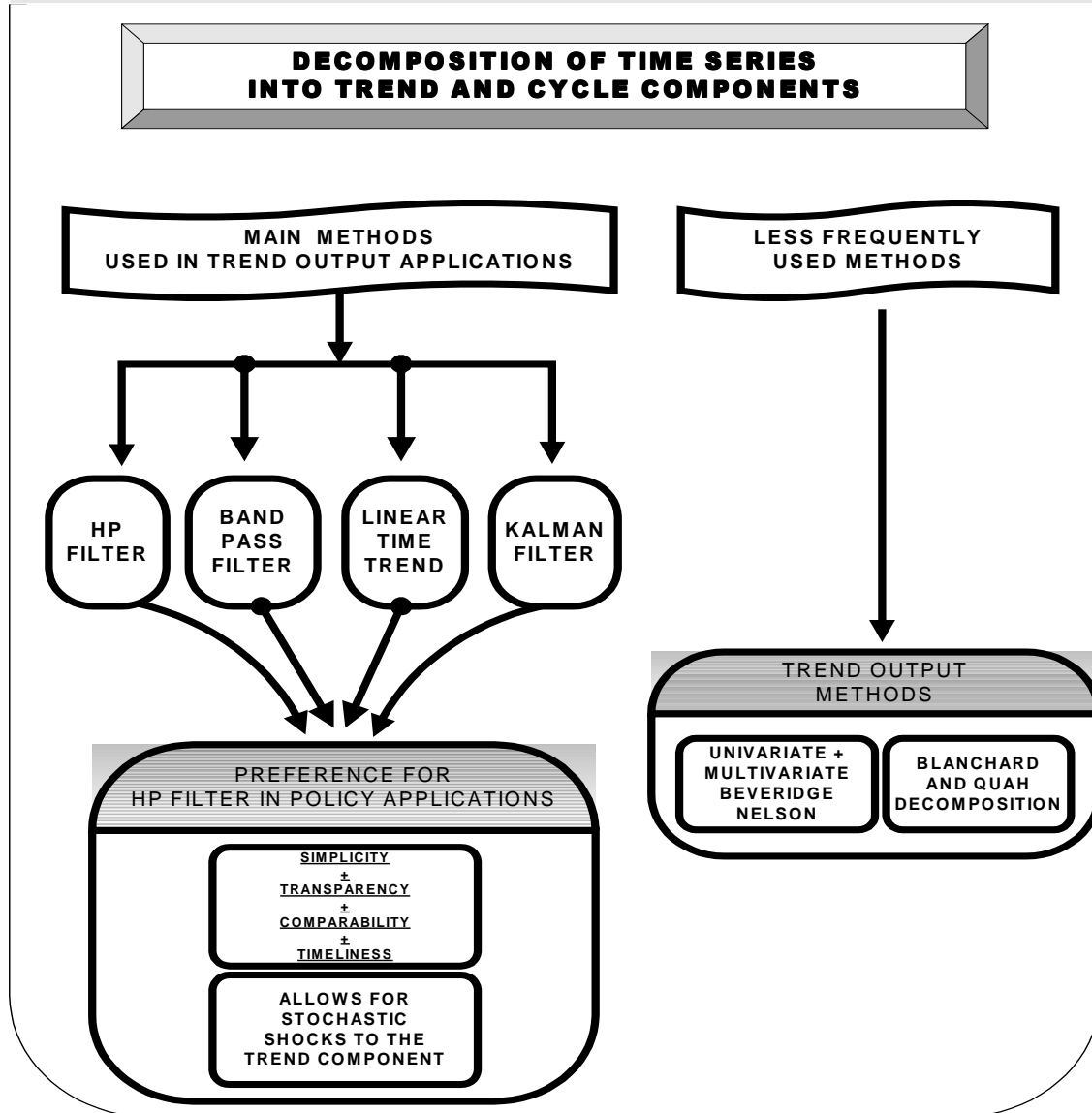
While both the economic and statistical approaches are clearly conceptually different, it is important to retain their independence when it comes to the estimation phase. In this regard, as discussed in section 1.4, one should be aware that with the type of production function commonly used, applying univariate statistical filters to the inputs instead of the output directly will by itself not generate a different potential output estimate. The production function approach can only generate different estimates of growth potential if alternative trend extraction methods are used for the inputs.

1.1 : STATISTICAL TREND ESTIMATION METHODS

A large variety of statistical methods for trend decomposition are currently available. It is not the intention of this paper to take an exhaustive look at all of the methods but to pick those which are most commonly used in economic research. Diagram 1 below gives a list of those methods which will be examined as well as stressing the particularly interesting features of the Hodrick-Prescott (HP) filter approach. Section 1.1.1 goes on to present the HP filter and characterises its main features. A more detailed description of this method is given in Annex 1 where the selection of the smoothing parameter λ and its impact on the extraction of the cyclical component are examined more closely. Attention is also given to the so-called end point bias problem. In the subsequent sub-sections, the Hodrick-Prescott filter is compared with

other trend estimation methods, such as the band pass filter, linear time trend methods and the unobserved components approach. More sophisticated methods, such as the univariate and multivariate Beveridge Nelson decomposition and an orthogonal decomposition suggested by Blanchard and Quah are also examined

DIAGRAM 2 : STATISTICAL TREND ESTIMATION METHODS



1.1.1 THE H-P FILTER

Amongst the many univariate statistical methods which are currently available, the Hodrick-Prescott (H-P) trend estimation method is widely used as a simple technique for the detrending of macroeconomic time series. This method basically uses a long-run, symmetric, moving average to detrend a particular series, in this case output. Applying the latter filter is by now a standard method of extracting trends and is used frequently in academic applications and also by many of the international financial

and policy making institutions. With regard to its application to the output series, the H-P filter is obtained by minimising fluctuations in actual around trend output subject to a constraint on the variation of the growth rate of trend growth³.

The H-P filter has some useful characteristics for its application in calculating trend output in that firstly, it allows for stochastic shocks to the trend component; secondly, it is simple, transparent, needs minimal judgemental intervention and is therefore easily reproduced and finally, it provides a uniform framework for the calculation of trend output for each of the EU's Member States and for the EU15 and Euro area aggregates. However, on the negative side, a statistical filter such as the H-P method will only perform well for relatively stable economies in the absence of large shocks, and less well in interpreting extraordinary circumstances, where economic methods for calculating the trend should have an advantage. In addition, one must remain conscious of the underlying limitations of the method, which has, for example, been widely criticized in the literature for the arbitrariness in the choice of the smoothing parameter to be adopted and for other limitations such as its end-point bias problem.

1.1.2 BAND PASS FILTER⁴

³ The technical specification of the H-P filter imposes a trade-off between smoothness and fit: the smoother the trend output series, the poorer its fit to actual output and vice versa. This trade off is determined by the choice of the value for the Lagrange multiplier λ . The value of the multiplier λ also determines the smoothness of the trend estimates. A low value of λ produces trend growth estimates which closely follow actual growth and are therefore very volatile, while a high value of λ produces very smooth trend estimates which follow actual output less closely. In principle any degree of smoothness can be achieved with the HP filter by setting specific values for the smoothing parameter. Following what has become the norm in the academic literature on real business cycles and amongst practitioners, the Commission services set λ at 100. In terms of the length of business cycles affecting the cyclical component, a λ at 100 means that cycles shorter than 15-16 years are retained while cycles above 20 years are fully filtered out.

⁴ The idea underlying the band pass filter is as follows. Time series can equivalently be represented in the time domain as an infinite moving average process or in the frequency domain, namely as an integral over all their random periodic components from 0 to π as follows

$$y_t = \int_{-\pi}^{\pi} f(\theta) d\theta$$

Given this representation of the time series, the cyclical component could be calculated after determining the maximum cycle length that can still be regarded as a business cycle (e.g. a cycle with a period of 16 years corresponds to frequency $2\pi/16$) by giving a zero weight to periodic components $f(\theta)$ with $\theta \leq 2\pi/16$ and a weight equal to one to all periodic components with $\theta > 2\pi/16$. Let $\alpha(\theta)$ be a frequency response function with

$$\alpha(\theta) = \begin{cases} 1 & \text{for } \theta > 2\pi/16 \\ 0 & \text{for } \theta \leq 2\pi/16 \end{cases}$$

then, in the frequency domain the cyclical component would be represented as:

$$y_t^c = \int_{-\pi}^{\pi} \alpha(\theta) f(\theta) d\theta.$$

There exists a time domain representation of this frequency response function, i.e. there exists a filter $(1 - BP(L))$ with filter weights BP_h which can be found via the inverse Fourier transform of $\alpha(\theta)$ as

While, as made clear in 1.1.1, the Hodrick-Prescott filter has a lot of desirable properties, it is not however an *ideal filter* in that it does not have a sharp cut-off point at a specified cycle length. The Hodrick-Prescott filter takes cycles up to 15-16 years into account and then only gradually reduces the importance of longer cycles to fully eliminate cycles above 20 years. In an "ideal" band pass filter, a sharp cut-off point at a specified cycle length would need to be constructed. In recent years suggestions have been made to construct such ideal or band pass filters (see, for example, Baxter and King, 1995). These filters attach a weight equal to one to the selected cyclical components. They eliminate all cycles with a period larger than the maximum selected business cycle period by attaching a weight equal to zero to them. This is, in fact, only a theoretical possibility which is more difficult to implement in practice.

It is interesting to observe that the band pass filter suggested by Baxter and King shares some common properties with the HP filter. Firstly, it is also symmetric in order to avoid a phase shift of the filtered series; secondly, the filter weights are fixed in such a way that stochastic and deterministic trends are fully eliminated and thirdly, the resulting moving average filter is of infinite order. However, it is impossible to achieve such an ideal filter in practice with a finite set of weights. The smaller the number of weights used, the less sharp will be the cut-off property of the filter. For practical applications to finite time series, it is therefore also necessary to find a good approximation to this ideal filter. Moreover, there also exists an end point bias problem, with Baxter and King, after doing extensive sensitivity analysis, recommending to add six observations in order to eliminate this bias.

In general, the output gaps constructed with the Hodrick-Prescott filter resemble closely those based on the band pass filter if the same data extension is used. A test was set up to examine the similarity of output gaps obtained with the Hodrick-Prescott filter against those obtained with a band pass filter. For this test, the filter design for the band pass filter was modelled in such a way that it eliminated cycles larger than 16 years. Under these conditions, there is virtually no difference between the two output gaps, with correlation coefficients between the Hodrick-Prescott and the band pass output gaps for all EU Member States being very close to one. These results suggest, as found previously by Baxter and King for US GDP, that the Hodrick-Prescott filter is nearly indistinguishable from a band pass filter in practical applications with finite data.

1.1.3 LINEAR TIME TREND

An alternative method is the linear time trend method which builds on the basic assumption that GDP can be decomposed into a deterministic trend component and a cyclical component (this implies that trend and cycle are fully uncorrelated, which should be compared to the positive correlation found with the Hodrick-Prescott

$$BP_h = \int_{-\pi}^{\pi} \alpha(\theta) e^{i\theta h} d\theta .$$

In other words, the band pass filter leads to the following cyclical component

$$y_t^c = (1 - BP(L))y_t .$$

filter)⁵. However, it is now generally accepted that the trend component is also subject to stochastic or random shocks. More specifically, the existence of a unit root for GDP cannot be rejected (i.e. GDP is a non-stationary or trending variable). Consequently, if deterministic trends are used in order to calculate output gaps, there is a risk that stochastic trend components are not completely eliminated. In such circumstances, the linear trend method is misspecified and overestimates output gaps by partially allocating trend components into the cyclical component⁶. The Hodrick-Prescott filter on the other hand smoothes all trend components, deterministic and stochastic. In fact, both the Hodrick-Prescott filter and the band pass filter are designed to eliminate both stochastic and deterministic trends from the data and only leave strictly stationary components. Calculations show that even if a trend break is allowed for, the existence of a unit root can still not be rejected. However, allowing for a trend break does reduce the size of the output gaps produced by the linear trend method and makes them similar in size to the Hodrick-Prescott gaps.

One major reason why it is so difficult to reject the unit root hypothesis for GDP data may be the presence of a trend break with an otherwise deterministic trend. For example, Perron (1989) has demonstrated that by allowing for a single trend break or a trend shift in 1974, GDP for many industrialised countries can actually be modelled as stationary around a deterministic trend. However, this approach has been criticised as relying on an *a priori* known date for the trend break. More recently Perron (1997) has presented an estimation method that searches for the trend break which minimises the t-statistic used for testing for the presence of a unit root. Applying this procedure obviously gives a higher chance of rejecting the stochastic trend hypothesis. Tests for the presence of a unit root were again carried out on real GDP data, while allowing for a trend break. The tests show that, even taking into account a trend break, the hypothesis of a unit root over the period 1974 to 1998 cannot be rejected. With this method, significant trend breaks can be detected for most EU countries. In overall terms however, as stressed above, when trend breaks are allowed for, the size of the output gap using a deterministic trend is generally not larger than the Hodrick-Prescott estimated output gap.

1.1.4 UNOBSERVED COMPONENTS (UC) / KALMAN FILTER APPROACH

The Kalman Filter approach has been pioneered by Harvey (1989), amongst others, and assumes that macroeconomic time series are composed of distinguishable trend, cycle and erratic components⁷, which are not directly observable. If one is interested

⁵ **HOW DOES THE HODRICK-PRESCOTT TREND DIFFER FROM A LINEAR DETERMINISTIC TREND?** The trend growth rate generated with the Hodrick-Prescott filter is correlated with the actual growth rate, underlining the view that trend and cycle are not completely independent phenomena. The correlation coefficient is around 0.5 for most EU countries. The economic assumption underlying an exact or deterministic trend is of course that trend and cycle are completely independent phenomena.

⁶ To regard time series as being composed of a linear deterministic trend and a cyclical component had been the standard view until the early 1980's. In the 1980's, several time series studies (see, for example Nelson and Plosser, 1982) arrived at the conclusion that many macroeconomic variables - including real GDP - contain a unit root component or a stochastic trend which implies that the trend component in GDP is subject to irregular stochastic shocks, which have a permanent effect on the level of GDP. While this is now the standard view it is still accepted that it is difficult to distinguish empirically, with a high degree of precision, between deterministic and stochastic trends. While disentangling these effects is difficult, it is nevertheless the case that standard unit root tests generally support the view that trends are subject to random shocks.

⁷ The possibility to include a seasonal component exists and it has been shown that it should be considered as a first best approach (see, for example Maravall (1996)). In other words, it is preferable to use seasonally unadjusted series and incorporate a seasonal component as part of the model. Unfortunately, such series are not always available. In the case of the present work, seasonally adjusted series have been used.

in decomposing individual time series, such as real GDP, into trend and cycle (plus erratic) components within a univariate framework (i.e. by only using time series information from real GDP), then these components can be recovered from the actual observations by imposing sufficient restrictions on the trend and the cycle. This essentially requires assumptions on the functional form of these components and the structure of the error processes, including cross correlation properties. A multivariate extension of this approach is also possible which allows for the use of other empirical economic information, for example inflation, to assist the decomposition process.

UNIVARIATE MODELS : A typical macroeconomic series such as the log of real GDP (y_t) is assumed to be additively composed of a trend component, T_t , a cycle component c_t and an erratic component ε_t as follows:

$$y_t = T_t + c_t + \varepsilon_t \quad \varepsilon_t \sim NID(0, \sigma_\varepsilon^2) \quad t = 1, \dots, T$$

In the literature, the components are still nearly exclusively modelled as linear stochastic processes. The irregular component ε_t is simply a white noise. The trend component can be, for instance, a damped AR(1) process but the linear specification is more common. The cycle component c_t is an AR(2) process. Finally, in order to achieve identification of the overall model, it is usually assumed that the components are un-correlated with each other. Estimation of these dynamic UC-models can be performed using the Kalman filter approach. This requires setting some initial values for the parameters and re-formulating the model in State-Space format.

MULTIVARIATE MODELS: The above framework can be extended in many ways. For instance, it is possible to specify a model containing both UC and observable components such as explanatory variables or intervention analysis. The most general specification is the multivariate UC-model which can be obtained as a straightforward extension of the univariate case.

In such a multivariate framework there is the possibility to allow for economic content to guide the setting up of the system. For example, in the univariate UC model, the decomposition of output into trend and cycle is based on purely formal criteria. No further economic information is used in the identification process. It has been shown by Kuttner (1994) that supplementary equations can be added to the model by specifying additional measurement equations which contain hypotheses on the relationship between the (unobserved) cycle and other (observed) variables which are suggested from economic reasoning to be highly cyclical. One such variable is the change in the inflation rate, since many Phillips curve type models regard deviations of actual output from potential as an important explanatory factor for changes in inflation. This information can be used by adding another measurement equation to the system such as an inflation equation. Exploiting the dependence of output and inflation on a common (unobserved) output gap by jointly estimating the coefficients of the cyclical component should provide more information on the output gap. It must, however, also be stressed that the advantage of adding an extra equation rests crucially on a correct specification for the measurement equation. Within a maximum likelihood context a possible misspecification of the inflation equation could lead to biased estimates of the parameters of the cyclical component itself. One important finding of the Kuttner study for the US concerns the size of the output gap, which is reduced significantly by including an inflation equation.

SOME INITIAL RESULTS: Some preliminary work has been carried out using both the univariate approach as well as a simple multivariate extension of it and applying it to the real GDP series of the EU's Member States as well as to the US. Unfortunately satisfactory results have not been obtained for all countries. This is in line with previous experience (see Harvey and Jaeger, for example). Given the complexity of the estimation process (appropriate fixing of starting values, trend specification etc.) this does not mean that the results for these countries cannot be improved. The general finding of this initial analysis is that, taking the HP output gap as a benchmark, the output gaps generated with the UC method are generally highly correlated with the HP measure. It is also a general result that the standard deviation of the UC output gap is slightly smaller and that the HP method generates larger output gaps. In line with the results found in Kuttner for the US the amplitude of the cycle, in the UC method, is somewhat reduced if inflation is added to the model. These results should however be looked at cautiously since they may depend on the way the interaction between inflation and the cycle is specified and therefore more sensitivity analysis, using different Phillips curve specifications, seems to be necessary.

PRELIMINARY CONCLUSION ON UC MODELS : In overall terms, from a preliminary assessment of the use of both univariate and multivariate unobserved components models for the calculation of trend GDP / output gaps, unobserved components models seem to be an attractive tool to discriminate between cyclical and trend components in macroeconomic time series, though they are not free of a priori identifying restrictions which may be questionable. The most attractive feature of this approach is the choice it offers concerning the specification of trends and the possibility of using other empirical economic information for extracting cyclical components. However, from the work already completed using this approach, it has been found that results are specification dependent and additionally that obtaining acceptable results for some countries has proved difficult. This experience is so far restricted to the choice of the trend specification. Further experimentation with the cycle components may further strengthen this observation. Thus more work seems to be necessary to convincingly select certain types of models based on statistical criteria. Finally, the output gap estimates obtained with the UC model are highly correlated with the HP output gap and in general they tend to be somewhat smaller. The estimated cyclical components also turn out to be positively correlated with the change in inflation.

1.1.5 OTHER TIME SERIES METHODS - UNIVARIATE AND MULTIVARIATE BEVERIDGE NELSON + BLANCHARD AND QUAH DECOMPOSITION

This section surveys results on trend elimination based on three alternative methods, namely univariate and multivariate Beveridge Nelson decomposition and an orthogonal decomposition suggested by Blanchard and Quah. This sub-section summarizes the results of a study by Forni and Reichlin (1998), carried out for the Commission services. However, since these methods do not seem to give convincing results in practical applications, they are simply provided here for completeness.

1. UNIVARIATE BEVERIDGE NELSON

To extract a trend with the method suggested by Beveridge and Nelson (1981), two identification assumptions are made. These are:

- the trend (T) is a random walk
- innovations (i.e. shocks) of trend (T) and cycle (C) are perfectly correlated.

The Beveridge Nelson filter thus imposes a very specific functional form on the trend component and it is also assumed that trend and cycle are driven by the same shock. Such a filter would be suggested by certain types of economic hypotheses especially those which regard trend and cycle to be closely connected, such as for example real business cycle-models where the cycle is regarded as the response of the economy to a change in the growth component.

This filter has some nice theoretical and practical properties. For example, the filter equation depends on the stochastic process generating GDP. It only depends on past values of GDP, therefore no end point problem occurs. It nevertheless does not seem to be generating convincing results in practical applications, because it can generate very volatile cyclical components. Moreover, as is shown in Table 1 below, there could be negative correlations between the Beveridge Nelson cycle and the growth of GDP, especially in situations where the growth rate of GDP is positively autocorrelated, which occurs in practice.

TABLE 1 : SOME PROPERTIES OF THE BEVERIDGE NELSON TREND AND CYCLE

	GERMANY	FRANCE	NETHER- LANDS	UNITED KINGDOM
VARIANCE OF GROWTH RATES				
GDP	0.00050	0.00036	0.00039	0.00041
BEVERIDGE NELSON TREND	0.00030	0.00090	0.00120	0.00020
HODRICK-PRESCOTT TREND	0.00006	0.00017	0.00016	0.00002
CORRELATION OF CYCLICAL COMPONENT WITH GDP GROWTH RATE				
BEVERIDGE NELSON CYCLE	-0.587	-0.902	-0.927	0.247
HODRICK-PRESCOTT CYCLE	0.440	0.315	0.337	0.403

Source: Forni and Reichlin (1998).

2. MULTIVARIATE BEVERIDGE NELSON

With the multivariate Beveridge Nelson method, the trend is still regarded as a random walk. However, the stochastic shocks driving this trend will now be linear combinations of innovations of GDP and other variables (Forni and Reichlin use alternatively consumption, employment and interest rates) which are supposed to contain long run information useful for forecasting GDP. Like in the univariate case, trend and cycles will be correlated.

The problems encountered with the univariate Beveridge Nelson decomposition carry over to its multivariate extension. In fact a new problem occurs, since it turns out that the properties of the trend growth rate very much depend on the accompanying variable.

3. BLANCHARD AND QUAH (BQ) DECOMPOSITION

The general philosophy underlying the Blanchard and Quah (1989) decomposition rests on the idea that trend and cycle should emanate from largely independent sources. For example, one could regard the trend as being generated mostly by technological innovations, while cyclical movements could be regarded as the result of demand shocks. Given this hypothesis it is necessary to extract these two types of “shocks” from the data. Blanchard and Quah suggest a VAR analysis of a non-stationary variable (GDP) and a stationary variable (the unemployment rate)⁸ to decompose the reduced form residuals into uncorrelated permanent and cyclical components. Under these assumptions the BQ method determines trend and cycle with the following properties:

- the trend contains a random walk component;
- trend and cycle are completely uncorrelated;
- the trend only depends on current and past information;
- the filter is process dependent;
- orthogonality implies that the variance of the trend is smaller than the variance of the series.

As can be seen in table 2, the Blanchard Quah method seems to be more in line with other indicators of the cyclical position, but there also appears to be negative correlations and the output gap estimates depend strongly on the second variable which is used in the VAR analysis and there is no criterion on which the choice of this second variable could be based.

OVERALL CONCLUSION : The Beveridge Nelson and Blanchard Quah filters do not show a uniformly positive correlation with other business cycle indicators. The property of the Beveridge Nelson and Blanchard Quah methods that they can be negatively correlated with the trend shows up as a negative correlation with other cyclical indicators. This property certainly runs counter to any intuitive economic reasoning and makes it difficult to use them in practice.

⁸ This choice of variables is consistent with US time series properties, to which this analysis was first applied. The stationarity assumption for EU unemployment is obviously much more questionable.

**TABLE 2: CORRELATION OF MULTIVARIATE BEVERIDGE NELSON AND
BLANCHARD AND QUAH OUTPUT GAPS WITH OTHER CYCLICAL INDICATORS
(1965-95)**

	CAPACITY UTILISATION				PRODUCER SENTIMENT			
	D	F	NL	UK	D	F	NL	UK
BEVERIDGE NELSON (CONSUMPTION)	-0.31	-0.63	-0.10	0.60	-0.27	-0.70	-0.11	0.33
BEVERIDGE NELSON (EMPLOYMENT)	0.15	-0.35	-0.01	0.81	-0.20	-0.27	-0.13	0.43
BEVERIDGE NELSON (INTEREST RATE)	0.29	-0.35	0.12	0.36	0.18	-0.47	0.17	0.24
BLANCHARD QUAH (CONSUMPTION)	0.25	0.31	0.38	0.21	-0.01	0.30	0.12	0.04
BLANCHARD QUAH (EMPLOYMENT)	-0.16	0.25	-0.30	0.75	-0.24	0.57	-0.34	0.39
BLANCHARD QUAH (INTEREST RATE)	0.43	-0.28	0.28	0.18	-0.46	-0.60	0.35	0.34

Source: Forni and Reichlin (1998). {D = Germany, F = France, NL = Netherlands, UK= United Kingdom}

1.2 WHICH OF THE STATISTICAL TIME SERIES METHODS SHOULD BE USED FOR ESTIMATING TREND OUTPUT

While each of the methods described in 1.1 have their respective merits, it is clear that a choice has to be made as to which to use in the subsequent sections not only because of the clear difficulty of having an excessive number of statistical measures of trend output but also because these methods produce broadly comparable results when assessed in the context of output gap calculations (at least the 4 described in 1.1.1 - 1.1.4). In addition, while an exhaustive comparison is beyond the scope of the present analysis, it is possible to get some further insights by comparing the performance of the output gaps produced by the various methods against that of a range of other business cycle indicators. Given the poor results already referred to for the Beveridge-Nelson and Blanchard-Quah methods and the complexity of the Kalman Filter approach, this section confines itself to the HP Filter, Band Pass Filter, Linear Trend and Trend Break methods.

PERFORMANCE AGAINST BUSINESS CYCLE INDICATORS : The relative performance of the different methods can be examined on the basis of the respective correlation of the output gaps produced by the various methods compared with alternative business cycle indicators, such as the capacity utilisation rate or the producer sentiment indicator. In general a positive correlation between output gap measures and these indicators is to be expected. Such a comparison also provides information on whether the cycle length is suitable. It should be noted, however, that the capacity utilisation measure may not be comprehensive enough to characterise total economic activity since it focuses entirely on the manufacturing sector. The sentiment indicator is broader, since it includes industry sector confidence (1/3), consumer confidence (1/3), share prices (1/6) and construction sector confidence (1/6).

Table 3 presents correlations between a number of different measures for the output gap and the capacity utilisation and producer sentiment indicators. It is generally the case that the Hodrick-Prescott output gap is more strongly correlated with both the capacity utilisation rate and the sentiment indicator compared to output gap measures based on a deterministic trend method. Moreover, the turning points identified with the Hodrick-Prescott filter coincide with those shown in the business cycle indicators (Canova, 1999).

TABLE 3 : COMPARISON WITH BUSINESS CYCLE INDICATORS

	CAPACITY UTILISATION			SENTIMENT INDICATOR		
MEMBER STATE	HODRICK PRESCOTT	LINEAR TREND	TREND BREAK	HODRICK PRESCOTT	LINEAR TREND	TREND BREAK
BELGIUM	0.34	0.30	0.35	0.43	0.45	0.50
DENMARK	0.27	0.36	0.39	0.16	0.25	0.21
GERMANY	0.47	0.33	0.40	0.26	0.12	0.34
GREECE	0.32	0.01	0.04	0.33	0.26	0.22
SPAIN	0.30	0.24	0.43	0.28	0.38	0.04
FRANCE	0.74	0.69	0.56	0.51	0.45	0.33
IRELAND	-0.37	0.06	-0.21	-0.05	0.39	-0.03
ITALY	0.67	0.34	0.61	0.50	0.49	0.56
NETHERLANDS	0.27	0.09	0.25	0.24	0.25	0.23
PORTUGAL	0.11	0.06	0.06	0.34	0.32	0.35
UNITED KINGDOM	0.71	0.63	0.60	0.62	0.59	0.56

Note: The following methods for the estimation of output gaps are presented: (1) Hodrick-Prescott, (2) deterministic trend, (3) deterministic trend with break, i.e. the Perron method. The calculations could not be carried out for the three Member States that joined the EU in 1995 - Austria, Finland and Sweden - because sufficiently long time series for the capacity utilisation and sentiment indicators are not yet available for these countries.

SUMMARY STATISTICAL INDICATORS : Summary statistical indicators on each of the trend estimation methods that have been examined above are given in Table 4. The results show that the Hodrick-Prescott and band pass filters and the linear time trend methods (both with, and without, correction for trend breaks) produce symmetric results. The standard deviation of the gaps produced by the linear time trend method is larger than for the other methods. Both linear time trend methods also produce gaps which are less evenly distributed than is the case for the other methods.

TABLE 4 :STATISTICAL INDICATORS ON OUTPUT GAPS PRODUCED VIA DIFFERENT METHODS (EU COUNTRIES, 1974-98)

	Average	Standard deviation	Fisher coefficient	Pearson coefficient
Hodrick-Prescott filter	-0.1	2.3	0.2	3.9
Band pass filter	0.0	2.5	0.1	4.0
Linear time trend*	0.1	3.4	0.7	7.6
Linear time trend with trend breaks*	0.0	2.2	-0.2	5.6

*While these methods refer to a linear deterministic trend, other functional forms of deterministic trends i.e. polynomial etc, are also, of course, possible.

OVERALL ASSESSMENT OF STATISTICAL TREND METHODS: From the foregoing analysis there would appear to be no strong grounds for suggesting the use of a statistical detrending technique other than the Hodrick-Prescott filter. As the preceding analysis underlined, the advantages of the HP method are that it is simple and transparent and does not require any judgmental fine-tuning. It allows for the filtering out of deterministic and stochastic trends up to the second order. It does not induce shifts in the turning points of the series and the cyclical component that is retained by this filter is symmetric over the cycle. When the value for the smoothing parameter λ is set at 100, cycles with a length of up to 16 years are retained. If λ is set at 10 only cycles with a length of up to 8 years are kept - which would correspond more to the commonly accepted definition of business cycles - and the output gaps become smaller. The end point bias problem can be effectively addressed by extending the series with projections and the sensitivity of the forecast error appears to be limited.

The performance of the Hodrick-Prescott output gaps against other business cycle indicators - such as capacity utilisation or the sentiment indicator - is generally better compared to that of those generated by the two variants of the deterministic trend method. In comparison to the band pass filter, the Hodrick-Prescott filter is almost identical in that it has similar properties (i.e. it is symmetric and shares the end point bias problem) and the HP filter is as easy to compute. If the band pass filter is applied with a cut-off point at 16 years (comparable to the Hodrick-Prescott filter with $\lambda = 100$), the resulting output gaps are very similar with a correlation close to 1. The linear trend method is not widely used anymore since the hypothesis that GDP has a stochastic trend component is difficult to reject. The output gaps obtained via this method are large because the trend and cycle are assumed to be fully uncorrelated or independent. If trend breaks are allowed for - which is strongly suggested by the data - then the output gaps generated by the deterministic trend method are not uniformly larger than those of the HP filter.

As regards comparison with the other methods presented, preliminary experimentation with Kalman Filtering techniques suggests that, while additional testing is necessary, the output gap estimates obtained with the multivariate

unobserved components model are highly correlated with those of the HP filter. Finally, comparison between the HP approach and those of Beveridge-Nelson and the Blanchard and Quah decomposition are not really possible because of the lack of convincing results in practical applications using the latter methods.

To conclude therefore, it is important to reiterate that since the "true" trend and cycle components can never be deciphered, it is difficult to clearly establish any one detrending method as superior, with any final decision regarding the preferred technical method to be adopted being judged not only on its performance relative to other measures but also on criteria such as the purpose and use to which the final results are likely to be put to. However, for our purposes in this present paper and particularly the fact that, for ease of exposition, we must choose only one of the statistical trend methods for the subsequent analysis and comparison with the economic-based production function approach, it is felt, all things considered, that most features of the Hodrick-Prescott filter are acceptable. This is a view which also appears to be widely shared in both academic and policy making institutions given the "popularity" which this statistical trend estimation method continues to enjoy in the research work carried out by the latter organisations.

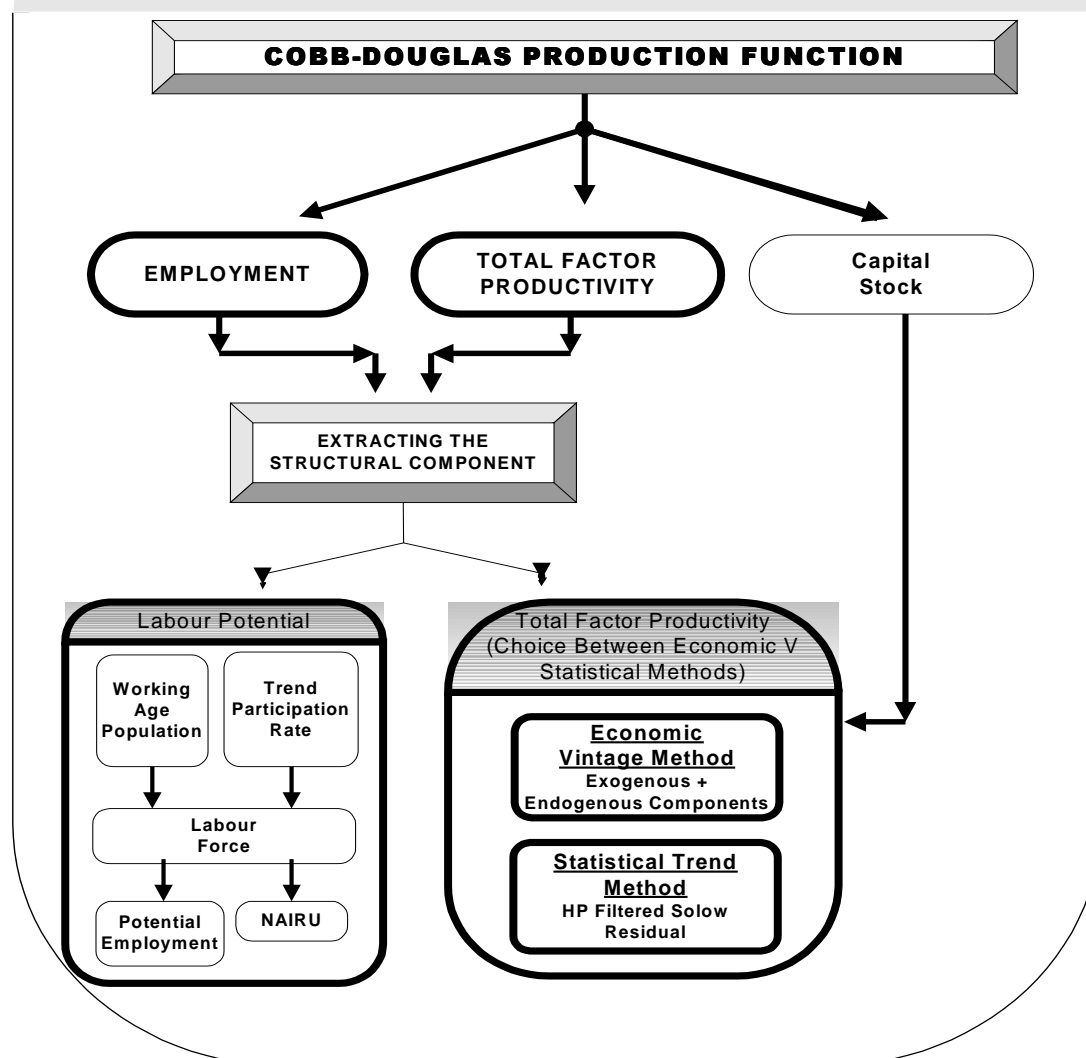
1.3 : PRODUCTION FUNCTION APPROACH

OVERVIEW OF PRODUCTION FUNCTION APPROACH : Instead of making statistical assumptions on the time series properties of trends and their correlation with the cycle, the production function approach makes assumptions based on economic theory. This latter approach focusses on the supply potential of an economy and has the advantage of giving a more direct link to economic theory but the disadvantage, as explained earlier, is that it requires assumptions on the functional form of the production technology, returns to scale, trend technical progress and the representative utilization of production factors. As shown in the overview diagram (i.e. diagram 3), with a production function, potential GDP can be represented by a combination of factor inputs, multiplied with the technological level or total factor productivity(TFP). The parameters of the production function essentially determine the output elasticities of the individual inputs.

To more closely examine the properties of the production function approach, the variant used in the Commission services' Quest II model is used as an example. The distinguishing feature of the QUEST II production function is the calculation of trend movements of total factor productivity via a conventional vintage approach. Otherwise, the widely used Cobb Douglas specification is imposed.

In section 1.3.1 the concept of potential output within a production function framework is discussed. With the Cobb-Douglas specification, it is necessary to estimate the trend components of the individual production factors, except capital. Since the capital stock is not detrended, estimating potential output amounts therefore to removing the cyclical component from both labour and TFP⁹. This is done in the subsequent sections with 1.3.2 and 1.3.3 discussing the methodologies for calculating potential employment / equilibrium unemployment and trend total factor productivity respectively.

DIAGRAM 3 : MEASURING POTENTIAL OUTPUT USING A PRODUCTION FUNCTION APPROACH



⁹ Since the capital stock is an indicator of overall capacity there is no justification to smooth this series in the production function approach. In addition, the unsmoothed series is relatively stable for the EU and the US since although investment is very volatile the contribution of capital to growth is quite stable since net investment in any given year is only a tiny fraction of the capital stock figures. In terms of the measurement of the capital stock, the perpetual inventory method is used which makes an initial assumption regarding the size of the capital / output ratio.

1.3.1. THE CONCEPT OF POTENTIAL OUTPUT AS MEASURED BY A PRODUCTION FUNCTION

COBB-DOUGLAS PRODUCTION FUNCTION¹⁰ : In more formal terms, with a production function, GDP (Y) is represented by a combination of factor inputs - labour (L) and the capital stock (K) -, corrected for the degree of excess capacity (U_L, U_K) and adjusted for the level of efficiency (E_L, E_K). In many empirical applications, including the Quest II model, a Cobb Douglas specification is chosen for the functional form. This greatly simplifies estimation and exposition. Thus potential GDP is given by:

$$(1) \quad Y = (U_L L E_L)^\alpha (U_K K E_K)^{1-\alpha} = L^\alpha K^{1-\alpha} * TFP$$

where total factor productivity (TFP), as conventionally defined, is set equal to :

$$(2) \quad TFP = (E_L^\alpha E_K^{1-\alpha})(U_L^\alpha U_K^{1-\alpha})$$

which summarises both the degree of utilisation of factor inputs as well as their technological level. Factor inputs are measured in physical units. An ideal physical measure for labour would be hours worked. Unfortunately this information is not available for all Member States and the statistical information is not easily comparable across countries. Therefore we measure labour input simply by the number of employees. This implies that any changes in working time will be reflected in the efficiency index. For capital we use a comprehensive measure which includes spending on structures and equipment by both the private and government sectors.

Various assumptions enter this specification of the production function, the most important ones are the assumption of constant returns to scale and a factor price elasticity which is equal to one. The main advantage of this assumption is simplicity. However these assumptions seem broadly consistent with empirical evidence at the macro level. The unit elasticity assumption is consistent with the relative constancy of nominal factor shares. Also, there is little empirical evidence of substantial increasing/decreasing returns to scale (see, e.g; Burnside et al. for econometric evidence). As will be explained below, our approach implies, however, a modest degree of increasing returns.

¹⁰ **CHOICE OF PRODUCTION TECHNOLOGY – WHY USE COBB-DOUGLAS ?** One of the big advantages of using Cobb-Douglas is undoubtedly its simplicity, in that it is easy to make sense out of the coefficients imposed. The Cobb Douglas assumption greatly simplifies estimation of output elasticities, conditional on an assumption on returns to scale. With a high average degree of competition in the goods market, the output elasticities can be equated to their respective factor shares. Thus, there is only one parameter to estimate. While a large variety of views on alternative specifications to the Cobb-Douglas view of constant factor shares are available, one needs to be aware of the implications associated with these alternatives. For example, if one chooses to adopt an elasticity of less than 1, one is left with the problem of explaining why wage shares have fallen recently. If one goes for the alternative assumption of using an elasticity of greater than 1, then the lack of econometric evidence to support using such a function needs to be taken into account. Consequently, given the difficulties associated with the alternatives, the Cobb-Douglas assumption of unity appears to be a reasonable compromise. In addition, of course, if one were to use a CES function with an elasticity of 0.8 or 1.2 the results would not differ very strongly from Cobb-Douglas. Finally, the aggregation problem associated with having a mixture of low and high skilled workers in the workforce would also appear to lend support to the Cobb-Douglas view. In this regard, if you aggregate over both sets of workers one would come close to Cobb-Douglas, with low skilled workers having a high elasticity of substitution (EoS) with capital (EoS > 1) balancing out the low EoS associated with high skilled workers (EoS < 1). High skilled workers have generally a low EoS since such workers are regarded as being more complementary to K. This view regarding the distinction between low and high skilled workers is supported by a paper by Krussell et al. published in *Econometrica* in September 2000.

The output elasticities of labour and capital are represented by α and $(1-\alpha)$ respectively. Under the assumption of constant returns to scale and perfect competition, these elasticities can be estimated from the wage share. The same Cobb-Douglas specification is assumed for all countries, with the mean wage share for the EU15 over the period 1960-2000 being used as the estimate for the output elasticity of labour, which gives a value of .63 for α for all Member States and, by definition, .37 for the output elasticity of capital. While the output elasticity for labour may deviate somewhat from the imposed mean coefficient in the case of individual Member States, such differences should not seriously bias the potential output results.

To summarise therefore, in moving from actual to potential output it is necessary to define clearly what one means by potential factor use and by the trend (i.e. normal) level of efficiency of factor inputs.

- **CAPITAL** : With respect to capital this task of defining potential factor use is straightforward since the maximum potential output contribution of capital is given by the full utilisation of the existing capital stock in an economy.
- **LABOUR** : The definition of the maximum potential output contribution of employment is more involved since it is more difficult to assess the "normal" degree of utilisation of this factor of production. Since there is no strict physical limit, the definition that we therefore apply is the level of employment consistent with stable, non accelerating, (wage) inflation (NAWRU) - (see Section 1.3.2 for details).
- **TREND EFFICIENCY** : Within the production function framework, potential output refers to the level of output which can be produced with a "normal" level of efficiency of factor inputs, with Section 1.3.3 showing how this trend efficiency level is measured.

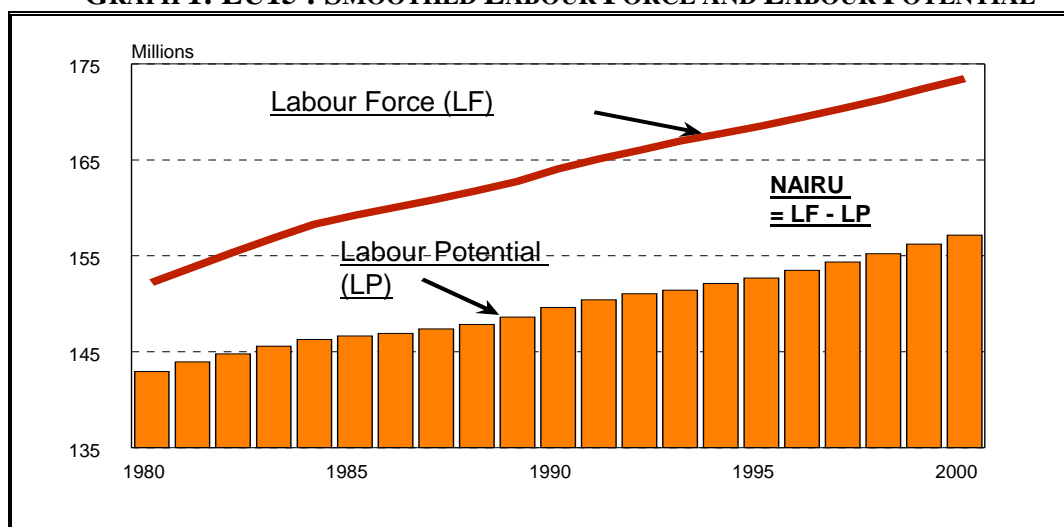
Normalising the full utilisation of factor inputs as one, potential output can be represented as follows :

$$(3) \quad Y^P = (L^P E_L^T)^\alpha (KE_K^T)^{1-\alpha}.$$

1.3.2 ESTIMATING THE LABOUR POTENTIAL COMPONENT

OVERVIEW : Potential employment is generated from a smoothed labour force series which is generated by applying a HP filtered participation rate to the working age population figures. With the smoothed participation rate leading to a less volatile labour force series, potential employment is then set equal to the labour force minus the NAIRU estimates for the respective countries. One of the big advantages of this approach is that it generates a potential employment series which is relatively stable whilst at the same time also providing for year-to-year changes to the series to be closely linked to long run demographic and labour market developments in areas such as the working age population, trend participation rates and structural unemployment.

GRAPH 1: EU15 : SMOOTHED LABOUR FORCE AND LABOUR POTENTIAL



TREND UNEMPLOYMENT : CALCULATING THE NAIRU / NAWRU

CONCEPTUAL DESCRIPTION OF PREFERRED NAIRU MODELLING STRATEGY: The production function approach requires estimates of "trend" unemployment rates, with economically calculated NAIRU's being employed for the present exercise instead of detrending the unemployment series using a simple statistical detrending method. The figures for the US are simply those calculated by the OECD using what is commonly referred to as the "Elmeskov" method¹¹ with the figures for the EU being estimated by the methodology described in the present section¹². The modelling approach adopted for the EU15 represents essentially a "hybrid" form of both Gordon's triangle model of inflation¹³ and of the bargaining framework underlying the labour market specification of the Quest II model, where wage rules are postulated, which identify productivity, reservation wage/participation rate changes and labour market tightness as major determinants of workers wage claims. Wages in Quest II are in fact determined as a weighted average of the reservation wage (unemployment benefits) and labour productivity plus an additional mark-up term that depends on labour market conditions. In this framework unemployment can be explained in terms of structural characteristics of the labour market, such as adjustment costs for labour, the replacement rate, the bargaining strength of trade unions and tax rates.

THEORETICAL LABOUR MARKET MACRO MODEL: In more specific terms, the structural unemployment estimates for the EU used for the potential output calculations were generated using a simple macro model of the labour market which consists of a wage equation and a labour demand equation. The structural

¹¹ The Elmeskov method in essence assumes that the change in wage/price inflation is proportional to the unemployment gap. It should be noted in this regard that the OECD are now moving to a new "NAIRU" methodology based on the use of the Kalman Filter.

¹² A detailed description of the methodology employed in calculating these NAWRU's / NAIRU's is given in Mc Morrow and Roeger (2000).

¹³ See Robert Gordon (1997).

unemployment rate defined in this way would be the equilibrium of that system after wages and prices have adjusted.

Wage Equation: Given the fact that market clearing is an unrealistic description of European labour markets, which are characterised by substantial involuntary unemployment, the wage equation does not therefore rely on such a framework. It is assumed instead that wages are set in an imperfectly competitive fashion. It should be noted that since the wage rule reflects wage setting in an imperfect market (e.g. union power, vacancy costs, search costs and efficiency wage considerations) the equilibrium reached in the labour market will generally be an equilibrium with involuntary unemployment. Standard macroeconomic models of the labour market (search-, union bargaining- and efficiency wage models) imply the following specification for the (generic) wage rule:

$$(4) \quad w = (1 - \beta) \frac{z}{1 - t_l} + \beta \left[MPL + v \frac{1}{LUR} \right]$$

Real gross wages (w) are determined by a reservation wage (z), the marginal product of labour (MPL) and labour market tightness as expressed by the inverse of the unemployment rate (LUR). The weight attached to these factors is determined by the bargaining strength of workers (β). It is important to note that, in particular, the reservation wage is difficult to measure. It is a complex economic concept which is determined both by the value attached to leisure but also by institutional features such as the level of unemployment benefits as well as their duration and alternative sources of income, such as income that can be earned in the shadow economy. To the extent to which the reservation wage is not taxed, labour taxes (including social security contributions) exert upward pressure on wages. In particular workers will require that (net) wages are set equal to or above the reservation wage.¹⁴ Therefore unemployment benefits and labour taxes can have an effect on the level of wages demanded by workers.

To get a solution for the “equilibrium” unemployment rate from this model one also has to look at labour demand.

Labour Demand Equation: Labour demand is derived from the marginal product condition which determines the level of real wages the firm is willing to pay for a given capital intensity (i.e. the capital to labour ratio) and the level of technology, as represented by total factor productivity. The real wages which are offered by the firm depend positively on capital intensity (which depends negatively on the real interest rate and corporate taxes) and on total factor productivity. Firms adjust employment such that the marginal product of labour is equal to wage costs. Wage costs consist of both salaries and social security contributions but they also include adjustment costs associated with search, administration and training. The costs associated with hiring and integrating/training workers turns the hiring decision into an investment decision

¹⁴ From a theoretical point of view an ideal indicator would be the net replacement ratio. Unfortunately, data on benefits is often not available over a sufficiently long period of time and obtaining a simple empirical measure for the replacement ratio is difficult since one must capture the effects of both benefit duration and coverage. In empirical work one is often forced to make the simplifying assumption that movement of tax rates reflect changes in the net replacement ratio which is a reasonable approximation if the reservation wage is not taxed and follows labour productivity.

for the firm and the marginal product generated by the worker must cover the capital costs of hiring. Assuming that adjustment costs for labour are proportional to wages ($v = v_0 w$), the marginal condition for employment becomes

$$(5) \quad MPL = w(1 + v_0(s + r))$$

Substituting (5) into (4) shows that unless $\beta = 0$ real wages will be set as a mark-up over the reservation wage.

$$(5a) \quad w = \frac{z_0}{(1 - t_l)} + \frac{\beta}{(1 - \beta)} \left[v_0(r + s + \frac{1}{LUR}) \right].$$

GENERATING STRUCTURAL UNEMPLOYMENT ESTIMATES: The above labour demand and supply model is capable of generating “involuntary unemployment” as a non-cyclical longer term outcome. The unemployment equilibrium is given by the following expression with the reservation wage (z), the tax burden (t), real interest rates (r), the bargaining strength of workers (β) and adjustment costs (v) clearly being the key structural variables which determine the NAIRU :

$$(6) \quad NAIRU = \frac{v_0}{\left[1 - (1 - \beta) \frac{z_0}{(1 - t_l)} - \beta(1 + v_0(s + r)) \right]} = NAIRU^{Barg}(z_0, t_l, r, \beta, v_0)$$

For further identifying the NAIRU / NAWRU we assume that price / wage inflation accelerates whenever the actual unemployment rate is below the NAIRU / NAWRU and vice versa.

$$(7) \quad \Delta w = a(NAIRU(z_0, t_l, r, \beta, v_0) - U) + \sum_{i=1}^K b_i \Delta w_{-i} \quad \text{with} \quad \sum_{i=1}^K b_i = 1$$

Because of real and nominal adjustment rigidities, wages and prices will in general deviate from their equilibrium levels. However, stability requires that the adjustment of wages and prices will be such that whenever the actual unemployment rate exceeds/falls short of the NAIRU, wages will tend to fall/rise, i.e. the coefficient “a” of the “unemployment gap” term in equation 7 above is positive. This equilibrating mechanism provides additional useful information from wage inflation which helps to identify the NAIRU, which is estimated using non-linear least squares regression. The estimate for structural unemployment is given by those coefficients of the NAIRU and the corresponding unemployment gap term which best explains wage inflation, given past levels of wage inflation.

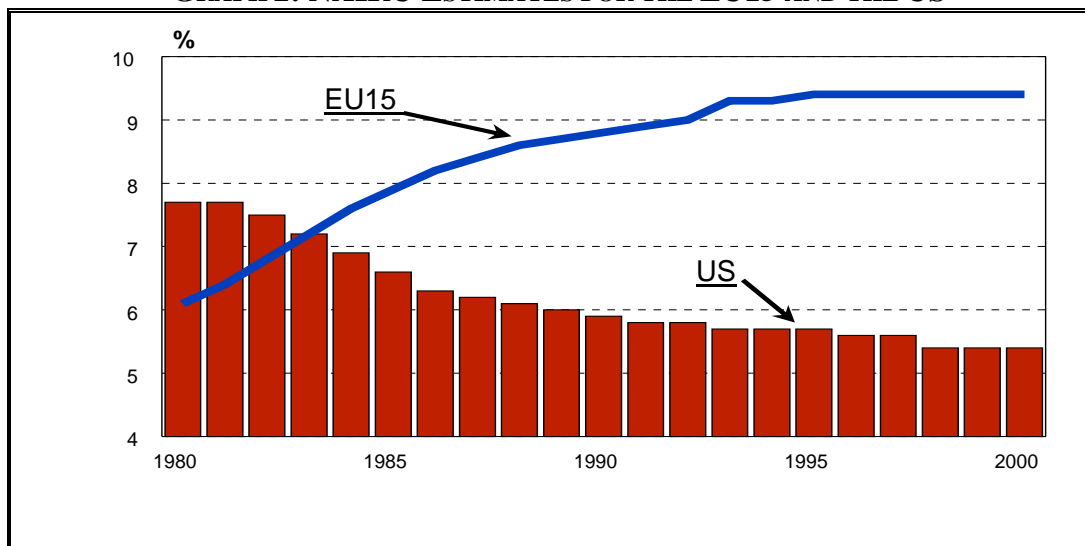
The estimates from equation (7) allow for an assessment to be made of the plausibility of the NAIRU both on theoretical as well as empirical grounds. The estimates of the coefficients of the NAIRU determinants should be consistent with theoretical restrictions imposed by the wage and the labour demand equations on the structural unemployment rate and the coefficients should be significant. Furthermore,

the unemployment gap term should have explanatory power for explaining wage inflation, given past wage inflation i.e. the coefficient α should be significant.

EMPIRICAL DIFFICULTIES IN IMPLEMENTING THE NAIRU MODELLING STRATEGY

It must be stressed, however, that the above model only serves as a theoretical reference point for selecting variables, it is not our intention to exactly estimate a specific model. The labour market has many more dimensions and data is not available of sufficient quality to conduct precise inferences. Currently we are only using tax rates and real interest rates as possible explanatory variables for the NAIRU / NAWRU and allow for breaks in the constant term of the regression to account for unobserved structural changes. In future work it is intended firstly to exploit new data sources which are becoming available, for example the European Household Panel Survey dataset and secondly to "augment" the existing method by using an unobserved components approach such as the Kalman Filter to capture the influence of some of the "missing" structural variables. On the basis of the present approach the EU15 NAIRU / NAWRU series is given below in Graph 2, with the OECD's NAWRU series for the US also shown.

GRAPH 2: NAIRU ESTIMATES FOR THE EU15 AND THE US

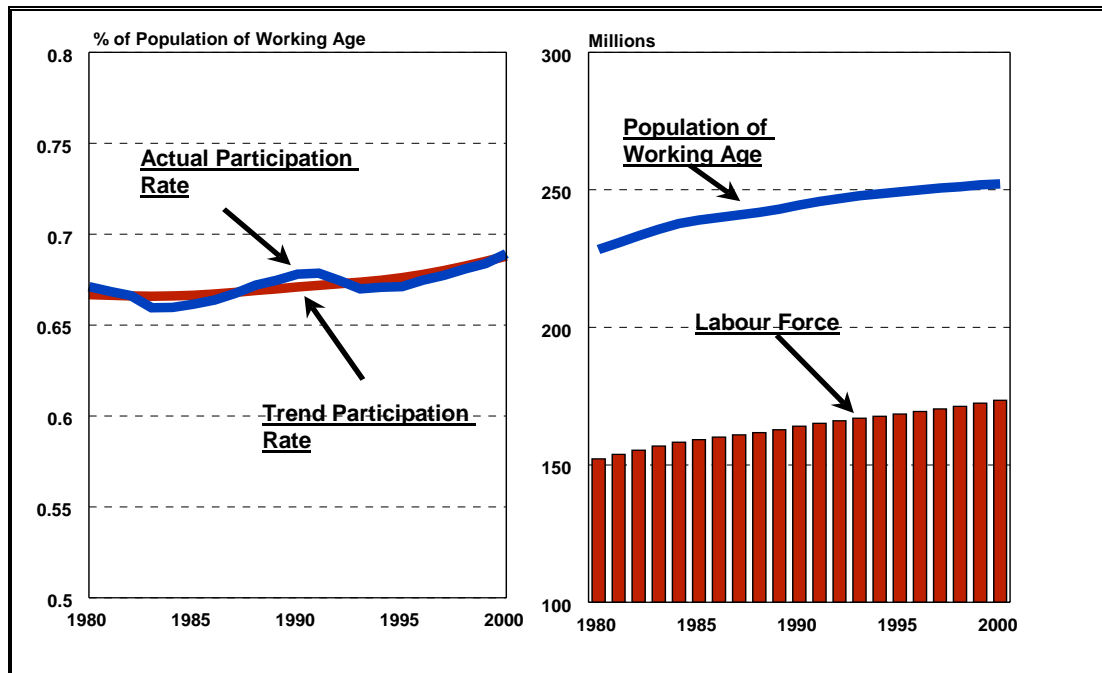


TREND LABOUR FORCE

As stated earlier, starting from the population of working age, the labour force trend is determined by simply calculating a HP filtered trend of the labour force participation rate. Use of the HP filter at the level of participation rates is, in our view, justified because of the difficulty in deciphering whether trends in participation rates for the different countries are driven by cyclical factors or by changes in other areas such as labour market legislation, with for example modifications regarding part time employment contracts potentially having big effects. However, resorting to a HP filter shows that the participation rate component of the calculations could be developed further, with any future work needing to take cognizance of both demographic (e.g. marital status) and structural factors (e.g. education, taxation) since they are both likely to play a role in the participation decision. With the trend

unemployment and labour force series generated, potential employment (i.e. the level of effective labour supply) is simply set equal to the labour force less the NAIRU.

GRAPH 3: EU15 : LABOUR FORCE DEVELOPMENTS



1.3.3 : TOTAL FACTOR PRODUCTIVITY - CALCULATING THE TREND

OVERVIEW: Given the quantitative importance of total factor productivity (i.e. the combined efficiency of both labour and capital) for output growth, any analysis of potential output must devote special attention to this issue. There are many hypotheses but generally not enough data of good enough quality to make precise statements. Hypotheses range from the standard view in neoclassical growth models which regards technical progress as completely exogenous, to so-called "endogenous" growth models which regard technical progress as the result of investment activities of firms, households and governments.

In the present paper the approach adopted is similar to the one used in Quest II. This approach essentially takes a "hybrid" view of technical progress, with the latter following not only an exogenous trend - which is assumed to be deterministic with possibly a trend break - but also depending on current and past investment activities. By incorporating a direct link between investment and productivity (as opposed to some other models which simply assume that technical progress is labour augmenting and use time trends to proxy its movements), vintage models such as Quest II are particularly useful for long term analysis involving the interaction of investment, technical progress and potential output (with new investment as the vehicle for introducing, productivity-enhancing, new technologies).

For the technology part of the QUEST II production function, a concept of embodied technical progress is used which allows for the calculation of a total factor productivity trend which is based on theoretic reasoning. Though the empirical results

are encouraging, it must, however, be emphasised that there is no consensus view on how to calculate these trends. Nevertheless, there is one definite advantage of using a theory-based measure for calculating total factor productivity trends instead of a HP filter. In theory-based methods, the total factor productivity trend is essentially calculated as the accumulation of certain types of investment, thus by definition it is a one-sided filter and therefore it does not require outside sample information i.e. unlike the HP filter it does not have an end-point bias problem.

DIFFICULTIES IN MEASURING THE TREND OF TOTAL FACTOR PRODUCTIVITY¹⁵:

Two fundamental problems arise with the measurement of trend total factor productivity. The first problem is related to the fact that the level of technology is not directly observable. As referred to earlier, even if the functional form of the production function is approximately correct, what can only be observed is the difference between GDP and an estimated combination of input factors, also known as the Solow Residual (SR) (in levels). Thus, this residual consists of a combination of excess capacity and total factor productivity:

$$SR = \frac{Y}{L^\alpha K^{1-\alpha}} = UC * TFP \quad (8)$$

The decomposition of the Solow Residual into capacity utilisation (UC) and a technological part depends on the view one adopts about determinants of technical progress and especially its stochastic nature. Extreme views are not uncommon amongst economists on this issue. For example, Real Business Cycle advocates would put UC to one and would interpret the observed fluctuations of the Solow Residual entirely as the result of exogenous shocks to technology, while Keynesian economists would allow for a larger role for capacity fluctuations and assume that TFP only has a negligible cyclical component.

Apart from this problem, a second complication arises in the decomposition of total factor productivity - whatever its precise definition - into a trend and a random component. As explained in the overview part of this sub-section, various views are possible. The standard view in neoclassical growth models regards technical progress as completely exogenous, i.e. it does not depend on past investment activities. Of course, there also exists many other endogenous growth hypotheses which try to explain total factor productivity from investment trends. In broad terms, one can at least distinguish the following three alternatives:

- Vintage models (used in QUEST II)
- R&D models (quality ladder models, variety of products models)
- Human capital models

Consequently, under these three alternatives, trend growth of total factor productivity would be determined either by the age of the capital stock (with average labour productivity being raised by new investment since the latter incorporates labour-embodied technical progress), the stock of R&D capital or the stock of human capital.

¹⁵ TFP is often used as a "rough" proxy measure for technological progress. It can only be "rough" since TFP is a residual term which includes both difficult to measure phenomena such as knowledge and innovation and changes in the degree of factor utilisation as well as acting as a dustbin for measurement errors for the capital stock and labour inputs as well as "new" economy gains in product quality.

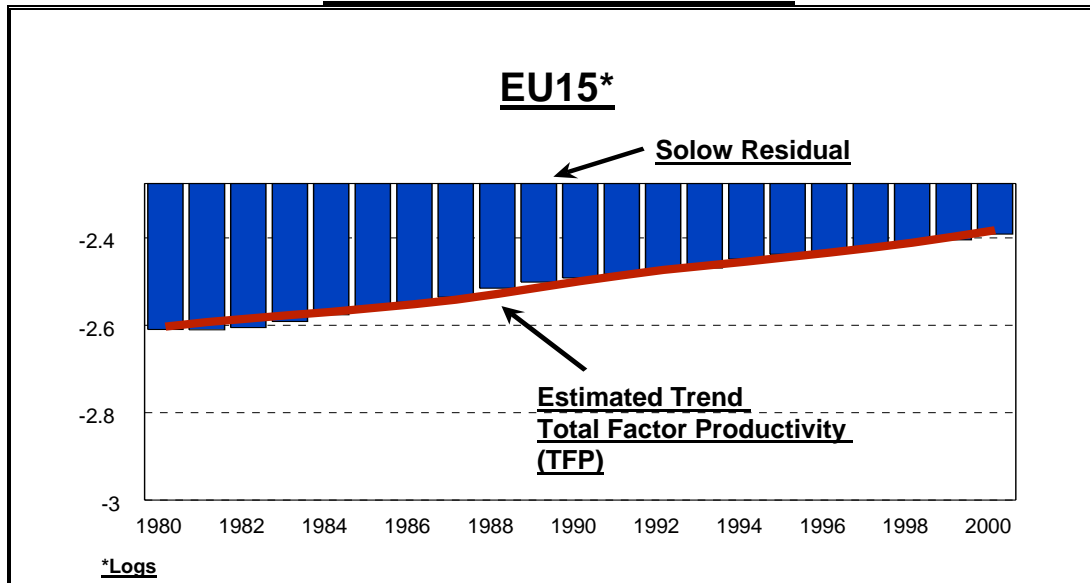
TFP METHODOLOGY ADOPTED FOR THE PRESENT EXERCISE : Trend TFP is estimated in the present paper using a simple vintage specification which tries to explain past movements in technical progress / TFP by linking it to changes in the average age of the capital stock.

LABOUR EFFICIENCY : In the absence of good data for the efficiency of labour, efficiency improvements are recovered directly from the data by estimating a deterministic trend where the possibility of trend breaks are allowed for :

$$(9) \quad \log(E_L) = \text{const} + \pi T + \pi_1 TB$$

CAPITAL EFFICIENCY : For measuring the efficiency of capital the vintage approach is adopted, both for pragmatic reasons (data on physical investment which are needed to implement this approach are available for all EU Member States and the US over a sufficiently long time span) but also because this specification seems to explain well the long-run movements of total factor productivity in nearly all EU countries as well as in the EU as a whole, the US and even Japan (see Table 5 and Graph 4). Other recent supportive evidence can be found in E. N. Wolff (1996), which looked at 6 OECD countries.

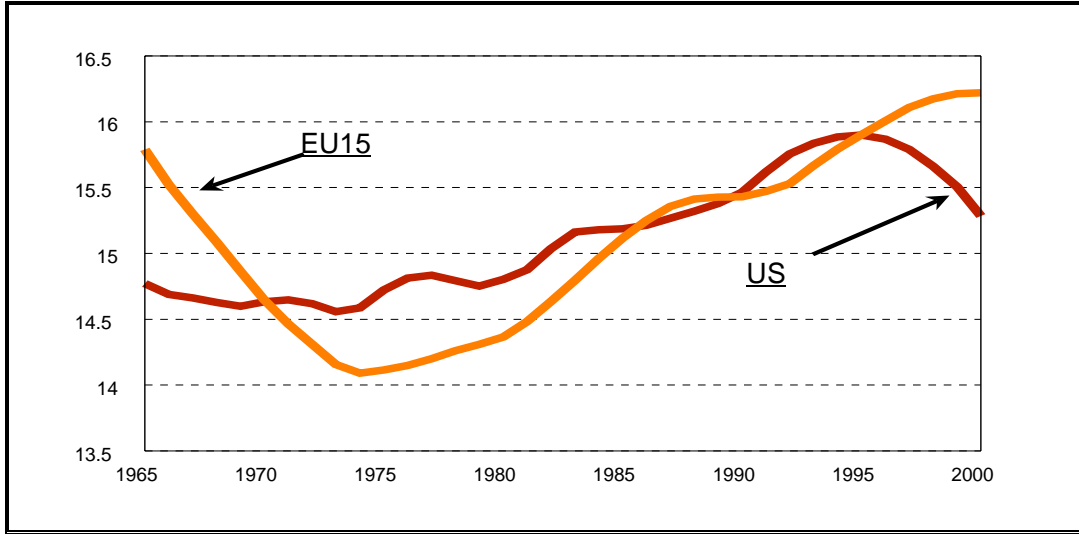
**GRAPH 4: COMPARISON OF SOLOW RESIDUAL AND ESTIMATED TREND
TOTAL FACTOR PRODUCTIVITY**



According to this vintage approach, technical progress is embodied in the latest capital vintages. Therefore investment not only has a capacity effect but also increases efficiency through embodiment effects. The impact of the history of past investment activities on the level of technology can be captured by a single indicator, namely the “mean age of the capital stock” (*agem*), defined as the total age of capital, divided by the capital stock. (see Röger, 1994, and Appendix 2 for further details).

$$(10) \quad \log(E_K) = c_0 - \theta * agem \quad \text{with : } agem \equiv \frac{Age(K)}{K}$$

GRAPH 4A: MEAN AGE OF CAPITAL STOCK 1965-2000



LABOUR + CAPITAL EFFICIENCY : Both the trend of labour and capital efficiency (i.e. E_L and E_K) can be estimated from TFP.

$$(11) \quad \log(TFP_t) = \frac{\pi}{\alpha} T + \frac{\pi_1}{\alpha} TB - \frac{\theta}{1-\alpha} \text{agem}_t + v_t$$

where π and $(\pi + \pi_1)$ measure the average growth rate of total factor productivity before and after a trend break. This means that only some big “technology shocks” that can easily be identified from the data are allowed for. Table 5 contains the regression results. From the results one can see that such shifts are important for some countries (such as Germany and Finland in the early 1990's, for example). The term θ gives the elasticity of total factor productivity with respect to the mean age of the capital stock.

A comparison of this equation with equation 1 reveals that the error term v_t also contains cyclical movements of capacity utilisation¹⁶ and labour hoarding, which suggests that it follows an AR(2) process. As can also be seen from Table 5, the regression coefficients have the right sign and are generally significant. The vintage hypothesis implies a relatively smooth trend for total factor productivity. This is not surprising, since the mean age of capital is itself a very slow moving variable. Because the mean age is lowered by current investment, the trend will be correlated with the cycle. These two properties implied by the production function approach are similar to the properties that are generated by the HP trend. It is also interesting to observe that the AR(2) coefficients of the error term exhibit the typical signs of a cyclical variable. This should be expected if cyclical variations in capacity utilisation are present in the data.

How can the TFP trend that is extracted with the vintage approach be characterized? It can be shown analytically that the trend growth rate of TFP is roughly

¹⁶ Some information on capacity utilisation rates in manufacturing, hours of work (also in manufacturing) and electricity consumption in the corporate sector is available that could potentially be used in the estimation process.

proportional to the growth rate of the capital stock itself. This is clearly shown in the following graphs which indicate that the approach tracks, in a satisfactory manner, the medium term movements of TFP.

**GRAPH 5 : EXTRACTING TREND TFP FROM THE SOLOW RESIDUAL
(GROWTH RATE OF CAPITAL STOCK, SOLOW RESIDUAL
AND TREND TFP)**

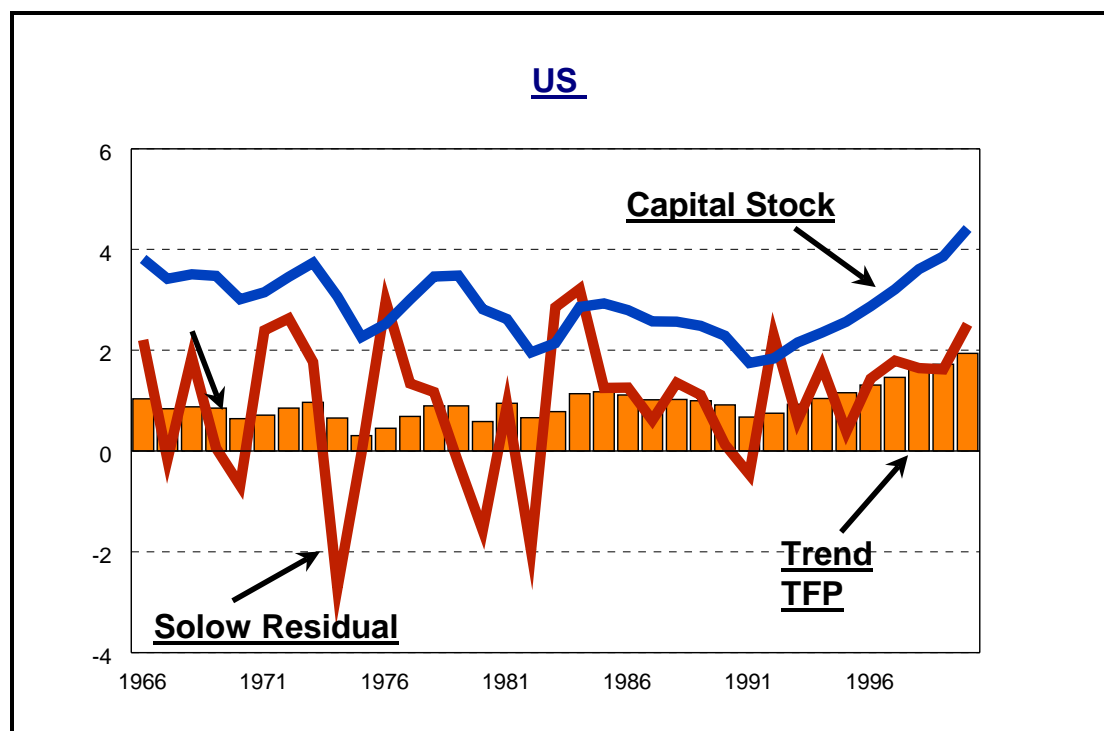
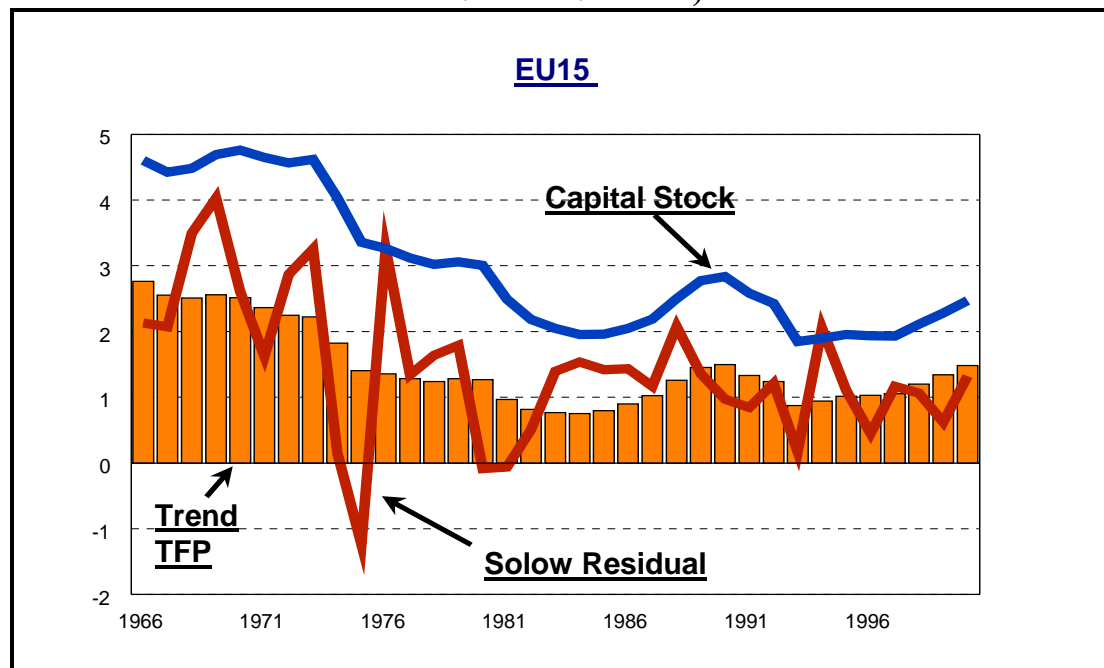


TABLE 5 : TFP REGRESSION RESULTS

	TIME TREND*	MEAN AGE OF CAPITAL STOCK **	INTERCEPT ADJUSTMENT	TIME TREND BREAKS	AR(1)	AR(2)	R-SQ (D-W STAT)
BELGIUM	0.011 (17.08)	-0.038 (-4.64)			0.56 (3.12)	0.04 (0.24)	0.99 (2.10)
DENMARK	0.006 (2.15)	-0.002 (-0.07)			0.81 (4.31)	-0.26 (-1.46)	0.98 (2.06)
GERMANY	0.018 (14.07)	-0.065 (-6.40)		-0.004 (1991) (-1.35)	0.75 (4.22)	-0.36 (-2.13)	0.99 (2.11)
GREECE	-0.003 (-1.86)	-0.07 (-12.41)		0.018 (1990) (4.49)	0.48 (2.19)	-0.31 (-1.83)	0.95 (2.14)
SPAIN	0.016 (14.42)	-0.023 (-2.68)		-0.012 (88 +98) (-4.37)	0.83 (4.52)	-0.22 (-1.21)	0.99 (2.00)
FRANCE	0.014 (14.78)	-0.022 (-2.48)			0.85 (4.63)	-0.25 (-1.52)	0.99 (2.14)
IRELAND	0.007 (2.12)	-0.025 (-3.84)		0.037 (1988) (7.23)	0.71 (4.15)	-0.28 (-1.72)	0.99 (2.02)
ITALY	0.015 (18.98)	-0.030 (-3.17)			0.78 (4.24)	-0.30 (-1.71)	0.99 (2.07)
NETHERLANDS	0.012 (15.86)	-0.049 (-6.55)			0.79 (4.62)	-0.23 (-1.45)	0.99 (2.00)
AUSTRIA	0.009 (8.02)	-0.019 (-1.65)			0.89 (4.79)	-0.10 (-0.57)	0.99 (2.02)
PORTUGAL	0.017 (14.40)	-0.051 (-2.87)			0.75 (4.45)	-0.33 (-1.96)	0.98 (1.98)
FINLAND	0.017 (9.37)	-0.011 (-2.56)	-0.06 (1991) (-3.49)	0.02 (1992) (3.20)	1.04 (6.61)	-0.55 (-3.50)	0.98 (2.02)
SWEDEN	0.008 (9.95)	-0.023 (-1.97)	-0.03 (1991) (-2.34)	0.017 (1992) (3.88)	0.92 (5.07)	-0.32 (-1.73)	0.98 (1.92)
UK	0.013 (14.59)	-0.007 (-0.46)			0.86 (5.12)	-0.42 (-2.59)	0.98 (2.01)
EU15	0.015 (59.37)	-0.046 (-11.39)			0.79 (4.67)	-0.34 (-1.99)	0.99 (1.94)
US	0.008 (9.07)	-0.034 (-3.29)		0.004 (1981) (1.72)	0.58 (3.59)	-0.37 (-2.29)	0.99 (2.01)

*This time trend is included to try to pick up the trend growth of TFP over the long run. This is a deterministic time trend as compared with the HP filter which is a stochastic trend. It is included since embodiment effects as proxied by the mean age of the capital stock do not capture long term trends - the age of the capital stock picks up essentially medium term cycles. In addition to the time trend a number of dummy variables are included which pick up trend breaks. The inclusion of a time trend and dummy variables means that the model used to pick up the trend growth of TFP can be characterised as one of deterministic trends with breaks.

**Coefficient on Mean Age of Capital Stock (AGEM) is negative (as AGEM increases, TFP decreases).

1.4 STATISTICAL AND ECONOMIC APPROACHES COMPLEMENT EACH OTHER AND SHOULD BE KEPT METHODOLOGICALLY DISTINCT

This section examines the issue of whether it is desirable to express a preference for the use of either statistical or economic methods for calculating potential output. The results presented in later sections of this paper suggest that there may be some grounds for such a rationalisation since, except for cyclical turning points, the estimates for both growth and output gaps, for both the US and the EU, are not dramatically different using either the economic or statistical approaches. While such a rationalisation would clearly be operationally much more efficient and less confusing for policy makers, it would mean either unequivocally selecting one of the two methods (HP V PF) as being superior or deciding that the two approaches should be combined in some way to produce a form of "hybrid" method, with for example the PF estimates being produced through recourse to HP filtered inputs. While the use of one "ideal" method has its attractions, on the other hand it should be underlined that both the statistical and economic approaches have natural advantages in particular policy domains, with the HP filter being particularly well suited to policy surveillance areas requiring rapid and non-judgemental updating and with the PF approach being very adept where more economic rationale is required such as in the area of medium term analysis.

IS IT POSSIBLE TO MAKE AN OBJECTIVE METHODOLOGICAL COMPARISON BETWEEN THE HP FILTER AND PRODUCTION FUNCTION APPROACHES ? : With regard to the underlying methodologies, there are clear differences in terms of the filtering techniques used in the respective calculation methods. The production function approach can be regarded as a backward filter, with both the capital stock and the age of the capital stock represented by moving averages of *past* investment and capital respectively. Therefore, with the production function approach, the boom in the EU in the late 1980's, associated with high investment rates, leads to an increase in potential output. There may consequently be a risk that use of the PF approach could result in the underprediction of the size of any positive output gap at the end of a long economic expansion. In contrast, the H-P approach is based on a symmetric filter and uses information not only from the late 1980's but also up to the mid 1990's in determining potential output at the beginning of the 1990's. Therefore since the HP filter uses both past and future information sets, it more strongly emphasises the boom character of the economic situation in the late 1980's. However, as against this, the HP filter could overpredict the size of output gaps just before a severe economic downturn, if the recession is caused by a large exogenous shock. The recessions in Finland and Sweden in the early 1990's could be examples where the HP filter leads to excessive smoothing and does not properly take into account a drop in potential output due to restructuring needs. Given these sharp contrasts in terms of the operation of both methods, it would appear, a priori, that different filtering philosophies make it very difficult to objectively favour the use of one method over the other.

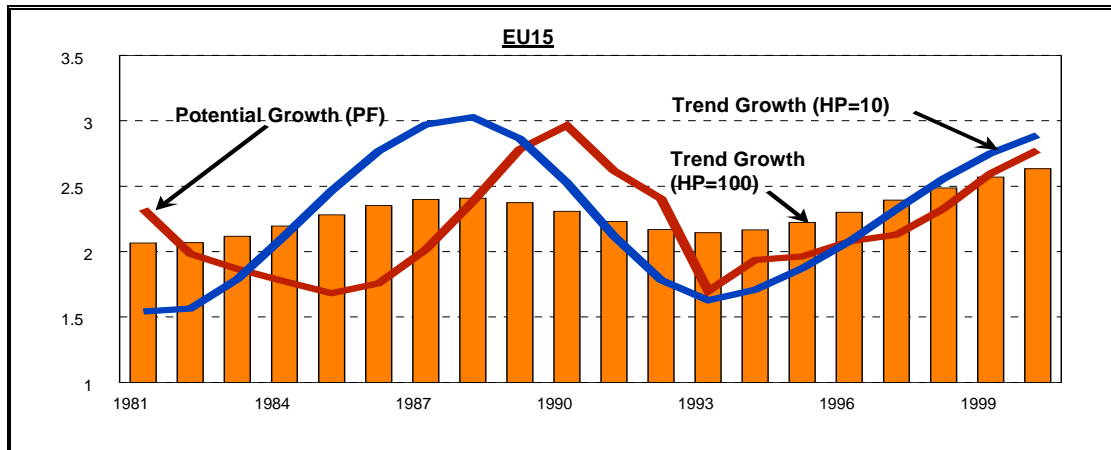
While at a methodological level both methods appear distinctive, operationally it can be shown that for the HP filter these differences are merely a matter of construction. In this regard, it is important to underline that the big difference between the two methods is the length of the cycles that are taken into account - in the case of the PF

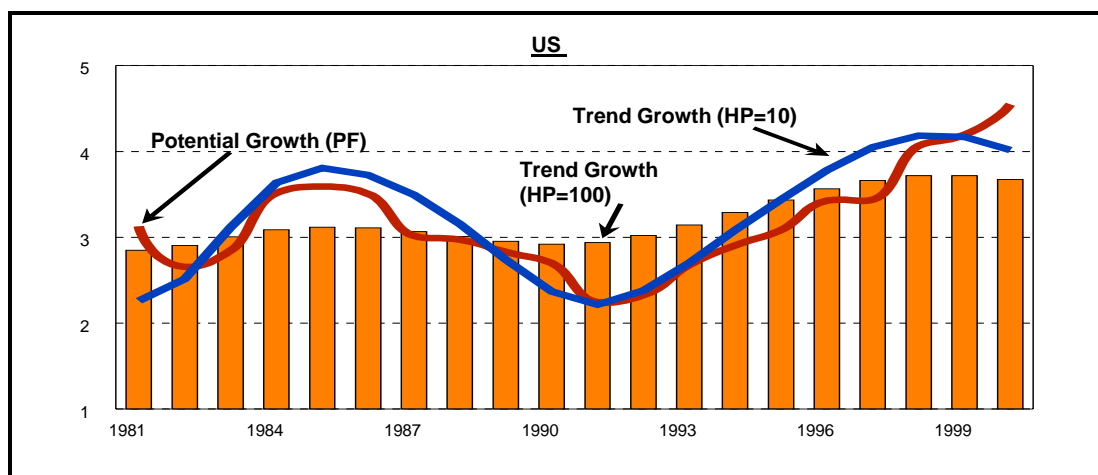
approach it is generally a normal business cycle of 7-8 years, with the HP filter removing cycles with a duration of up to 16 years. However, if one sets the smoothness parameter (λ) in the HP filter method at 10 (which corresponds to a smoothing parameter of 1600 for quarterly data which is typically used in business cycle research) rather than $\lambda = 100$, as is used for the calculations in Section 2, the HP filter can also produce cycle lengths which are similar to those of the PF method. When this is done, as can be seen from Graph 6, the volatility of the trend output figures produced by the HP filter are remarkably similar to those of the potential output trend produced by the production function method for both the EU and the US.

While Annex 1 discusses in detail this issue of the appropriate smoothing parameter to be used, here all that needs to be stressed is that the choice of 100 was dictated by the need to respect the conventions established in the literature. In addition, such a parameter value has been adopted to ensure that changes in trend growth over time are kept to a minimum, with these stability characteristics being an important feature in certain policy domains. Implicit in this view is that all trend extraction methods exhibit some short run cyclical fluctuations with no method guaranteeing that the trend path is correct. Consequently, if one accepts this view that all potential growth estimates have unavoidably a degree of cyclicalities included, it is particularly important to use as long a series as possible when calculating such structural estimates, with the smoothness parameter of 100 ensuring that a period longer than that usually associated with a typical business cycle is taken into account.

However, one of the big disadvantages of this HP filter approach (with $\lambda = 100$) is that it may fail to pick up signs of a break in the long run pattern until well after the first indications start to appear. This is where the PF method can complement the information coming through from the HP filter by looking at trends over a shorter period and by allowing those trends to be decomposed into economically relevant contributory factors. For to ensure that the PF method is really adding some complementary information to what policy makers already know from the HP estimates, it is important to use HP filtered inputs as little as possible in the PF method. Finally, while both the HP and PF methods both suffer from procyclical biases, the big difficulty of course with the PF method is that it may be more prone to a greater procyclical bias than that of the HP method since its time horizon is that of a single business cycle. This latter issue is discussed in more detail in section 2.2.

GRAPH 6: IMPACT OF DIFFERENT SMOOTHING PARAMETERS FOR THE HP FILTER





IS THE "HYBRID" SUGGESTION THE WAY TO PROCEED OR SHOULD THE APPROACH BE TO RETAIN BOTH METHODOLOGIES IN AS DISTINCTIVE A FORM AS POSSIBLE, WITH POLICY MAKERS CHOOSING BETWEEN BOTH METHODS FOR SPECIFIC POLICY APPLICATIONS?: The production function methodology utilised in this paper for estimating potential output avoids the use of HP filtered inputs wherever this is feasible. Both methodologies are kept as distinct as possible with in fact the only input which is statistically derived being the trend participation rate because of the large uncertainties associated with the economic-based alternatives in calculating the latter variable. A key area where this estimation philosophy is used in this paper is in the modelling of TFP where an economic approach is adopted (i.e. the vintage method) whereas most other international organisations use a statistically derived proxy for trend TFP (i.e. a HP filtered Solow Residual). This paper is therefore clearly against the "hybrid" approach. This position is based on the view that if one uses HP filtered inputs in the PF method the information content of the resultant potential output series is often very little compared with simply using a HP filtered output series from the outset. This is particularly the case if one uses a statistically derived trend TFP estimate in the PF method since the latter component in general constitutes over 50% of overall GDP, at least in the case of the EU.

In addition, it should be emphasized that applying a production function approach to calculating potential output and output gaps should not necessarily lead to significantly different results to those obtained via simple statistical methods such as the H-P filter. A gain from using a production function approach can only be expected if it is firstly easier to extract cyclical components from input factors (i.e. is it easier to decompose employment / unemployment and total factor productivity into their trend and cyclical components) than from GDP itself; secondly, if it seems necessary to apply very different detrending (i.e. filtering) methods to the individual inputs; or finally, if there is information available on the individual input factors which facilitates the decomposition at a more disaggregated input level. To put it differently, by applying a filter to GDP directly, one implicitly assumes that all input factors of a production function should be filtered with an identical filter. This could justifiably be regarded as an excessively restrictive assumption¹⁷.

¹⁷ In overall terms what this paragraph is stressing is that if one decides to change approaches one is well advised to move completely to a PF method since one does not get very different results using a "hybrid" approach, which uses elements from both methodologies, since a large proportion of the cyclical variation is still being calculated by one or other methods. In fact, as explained in the text, the difference between a production function approach and a direct filtering of GDP will be trivial if one

SHOULD BOTH METHODS BE REGARDED AS SUBSTITUTES OR UTILISED AS COMPLEMENTARY SOURCES OF POLICY RELEVANT INFORMATION ? :

Given the respective merits of both the statistical and economic approaches alluded to above, it is the considered view of this paper that the HP and PF methods should both be retained for analysis purposes since they can provide useful, complementary, information which is of interest to policy makers. In this regard, to achieve the maximum informational benefit, both methods should be kept methodologically distinct with the PF method making as little recourse as possible to statistically derived inputs. Furthermore, in the particular domain of estimating potential output, excluding the use of the HP filter in favour of the economically more appealing features of the PF method may be shortsighted since any additional information which can be garnered from a perusal of both estimates is useful when one is talking about an indicator which is self-evidently of crucial importance in terms of evaluating an economy's overall structural performance. While the PF method is clearly more economically respectable and perhaps following proper detailed analysis may prove superior to the HP filter in many practical applications, it must be reiterated that the calculation of potential output is dogged by the fact that it is unobserved and so must be calculated, with all the attendant problems and judgemental choices to be made in the latter estimation process, some of which are highlighted in later sections of this note.

applies a linear filter with fixed weights either to GDP itself or to its individual components in the case of a Cobb Douglas production function. Let $F(\lambda)$ be a filter with weighting scheme λ , then applying this filter to y (lower case letters denote logarithms of the corresponding capital letters) is identical to applying the same filter to all individual components :

$$F(\lambda)y = F(\lambda)uc + \alpha F(\lambda)l + (1 - \alpha)F(\lambda)k + F(\lambda)tfp$$

SECTION 2

POTENTIAL OUTPUT AND OUTPUT GAP ESTIMATES : HP FILTER V **PRODUCTION FUNCTION APPROACHES**

INTRODUCTORY REMARKS Section 1 discussed the various calculation methods which are available for extracting the trend component from a particular time series. In this section we will make a direct comparison between the preferred statistical detrending method from section 1, i.e. the Hodrick-Prescott (H-P) filter and the economic based production function (PF) approach. In section 2.1 we begin by looking at the potential output estimates produced by both of these methods for the US and the EU. Given that the distinguishing feature of the PF approach suggested in this paper is the vintage method for extracting the trend TFP component, Section 2.2 looks at the operation of this approach in greater detail: firstly, in general terms by demonstrating the high degree of uncertainty associated with all TFP modelling approaches and secondly, by asking whether the vintage method does a good job in extracting the cyclical component or does it still suffer from a procyclical estimation bias. Finally, Section 2.3 gives the derived output gap estimates produced by both methods, as well as assessing the relative merits of both approaches in terms of the normal policy applications in which these output gaps are used, namely inflation and budgetary surveillance.

2.1 POTENTIAL V TREND OUTPUT DEVELOPMENTS 1981-2000

ESTIMATES OF POTENTIAL OUTPUT This sub-section presents estimates on the growth rate of potential output in the EU and the US based on the production function and the HP filter approaches. It is interesting to compare the PF estimates with standard filtering procedures such as the HP method. With a production function, potential output tends to be higher at the end of a boom and consequently the recession tends to be deeper compared to a symmetric filter¹⁸ such as the HP filter. As shown in Graph 7, this is especially noticeable in the EU for the period from the end of the 1980's to the beginning of the 1990's. The explanation for this is fairly straightforward, with the production function approach resulting in increases in potential output at the end of a boom period because of high rates of capital formation and consequently the economy is left with a lot of spare capacity at the start of a recession. In contrast, a symmetric filter smoothes output using past, current and future data points.

While the PF potential output estimates for the EU and the US presented in Graph 7 and Table 6 provide a good picture of the present output capacity of both economies, they should not however be seen as forecasts of medium-term sustainable rates of growth but more as an indication of likely future developments if one were to simply rely on extrapolations of past trends. Given that this point is stressed in greater detail in Section 4 of the present paper, here it is sufficient to simply say that if a country's potential growth is, for example, 4% in 2000, it can only be sustained at that rate in future years if none of the underlying driving forces change. Any medium-term assessment would need therefore to be based on a careful evaluation of the likelihood that present rates of growth for labour potential, productive capacity and TFP will persist over the time horizon to be analysed. Furthermore, while the potential output estimate is a measure of capacity in any given year, of course a rate of growth which is commensurate with this capacity may not be realised because of bottlenecks etc.

¹⁸ Symmetry is an essential property for a statistical filter in order to avoid phase shifts.

POTENTIAL OUTPUT UNCERTAINTY AT THE PRESENT TIME PROVIDES A STRONG JUSTIFICATION FOR RETAINING BOTH METHODS FOR ANALYSIS PURPOSES :

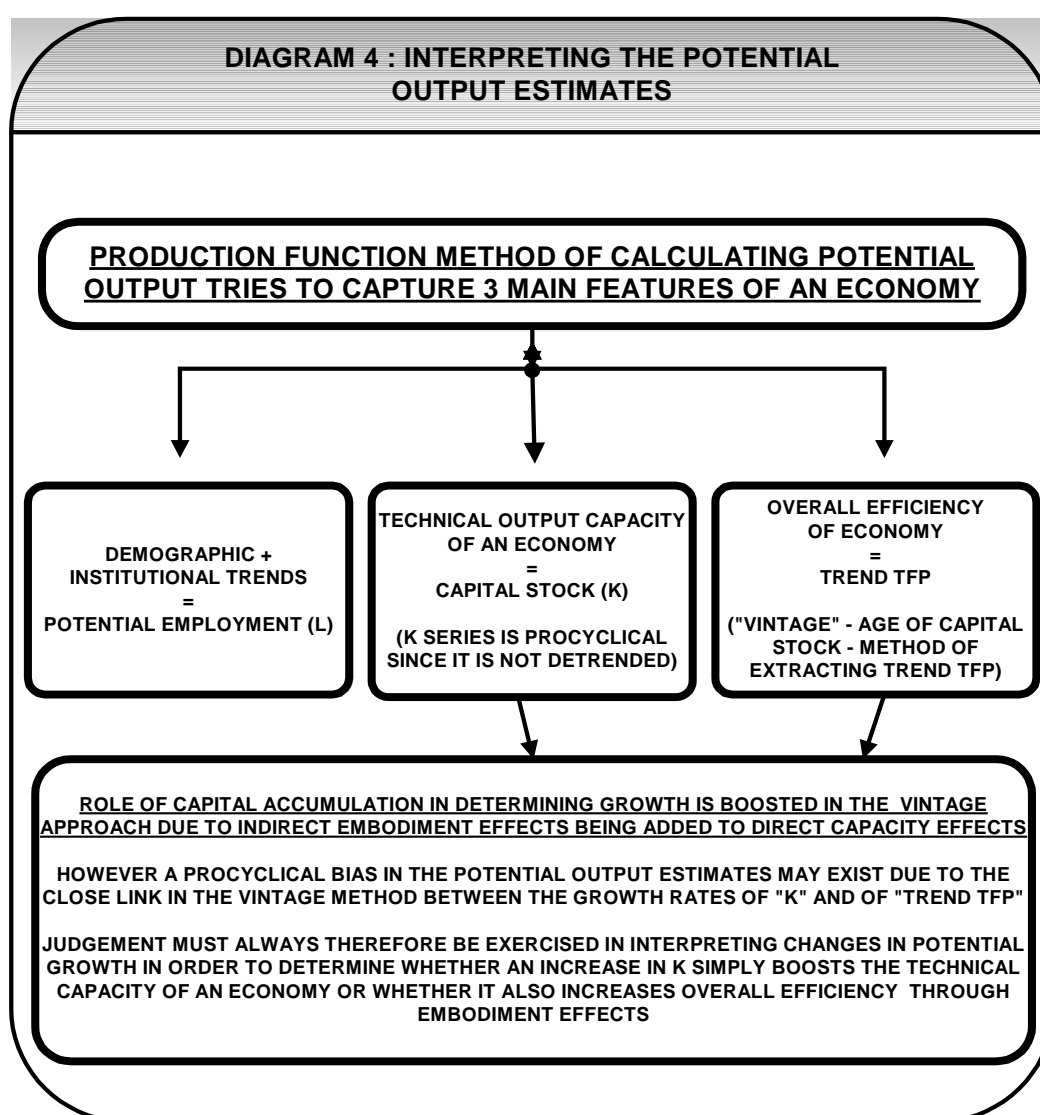
Trying to interpret what has been happening over the recent past in the EU and predicting the likely future evolution of the EU's economy over the next 3 to 5 years provides a good example of the importance of retaining both the HP and PF methods for analysis purposes. Both methods provide a different picture of developments in the recent past and of likely outcomes over the period 2001-2002. The production function method predicts a stronger increase in potential output compared with the HP approach over the period as a whole. This divergence can largely be explained by the emphasis put on investment for potential output in the PF approach. An increase in the investment to GDP ratio, as observed in recent years, not only has a capacity effect but also has positive effects on total factor productivity via embodiment effects. Therefore, under the condition that investment remains buoyant, a potential output growth rate of around 3% seems possible for the EU15. Further analysis with the production function approach in Section 3 suggests that embodiment effects as estimated with this production function are likely to underpredict potential growth in countries with high ICT¹⁹ shares in production and investment. Therefore, to the extent to which the ICT investment and production share increases in the EU15, the production function measure of potential output could even slightly underpredict the growth of total factor productivity in the coming years.

The present degree of uncertainty regarding the future path of potential output in the EU is in some ways reminiscent of the situation pertaining in the EU at the end of the 1980's. Like then, will we now experience a strong upward trend only to have it fall back again in the face of some major internal or externally induced shock or are we seeing the start of a strong process of catching up with the US ?. If one looks at the PF estimates one may well conclude the latter whereas if one believes the HP trend output series the outlook does not appear quite as "rosy". This is perhaps difficult to see if one just looks at the figures up to 2000 but if one extends, for illustration purposes, the PF and HP filtered series to 2002, using the Commission services Autumn 2000 forecasts, one sees the gap between the PF and HP methods widening slightly, with the PF method pointing to growth which is 0.4 of a percentage point higher in 2002. Is this differential the normal upward bias which is typical of the PF method in the expansion phase of a cycle or is it the start of something more significant, based on an acceleration in TFP growth which is indicated in Table 7 ?. At this stage it is impossible to say whether the PF or the HP filtered view is correct, with the overall conclusion for the future direction of the EU's economy from using both sets of estimates being one of guarded optimism.

PRODUCTION FUNCTION METHOD : GROWTH COMPONENTS : When comparing the growth contributions of labour, capital and TFP in the EU over the last two decades compared with the experience of the US over the same period, there are striking differences. As shown in Graph 8 and Table 7, the US boom in the 1990's is clearly driven by capital formation and an acceleration of TFP. All of the 1 ¼% points acceleration in potential growth between the first and second halves of the decade emanate from these two factors with the contribution from capital increasing by ½ a percentage point and TFP increasing by ¾ of a point. The contribution of labour to growth remained constant, compared to the 1980's. The figures for Europe are clearly

¹⁹ ICT = Information and Communication Technologies.

less impressive in terms of the overall growth rate acceleration and the compositional changes are also different to that of the US. While the growth acceleration is gathering pace in recent years, with potential growth estimated at 2.8% in 2000, when one compares the first and second parts of the decade the increase is more subdued. Over the period 1996-2000 the potential growth rate is estimated to have averaged 2.4% compared with 2.1% for 1991-1995. This acceleration in potential growth is also about a $\frac{1}{4}$ of a % point higher compared with the 1980's. In terms of composition, while the contribution from capital accumulation has been rising in the late 1990's, in terms of period averages TFP (0.2 increase) and labour (0.1 increase) were the sources of the upturn in growth²⁰. Finally, while positive growth signs are emerging in Europe these must be kept in perspective, with even the most recent acceleration in the growth rate of TFP and of the capital stock being on a much lower scale compared to that experienced in the US over the same period.



²⁰ With regard to labour productivity trends, the US has experienced an increase of nearly 1 $\frac{1}{4}$ % points between the first and second halves of the 1990's, to reach an annual average rate of nearly 3% for the period 1996-2000. The EU on the other hand has experienced a much more modest acceleration of a $\frac{1}{4}$ of a % point over the same period to reach an annual average rate of 2% for the second half of the 1990's.

**GRAPH 7 : POTENTIAL OUTPUT GROWTH RATES IN THE 1980'S AND 1990'S
(COMPARISON OF HP FILTER AND PRODUCTION
FUNCTION CALCULATION METHODS)**

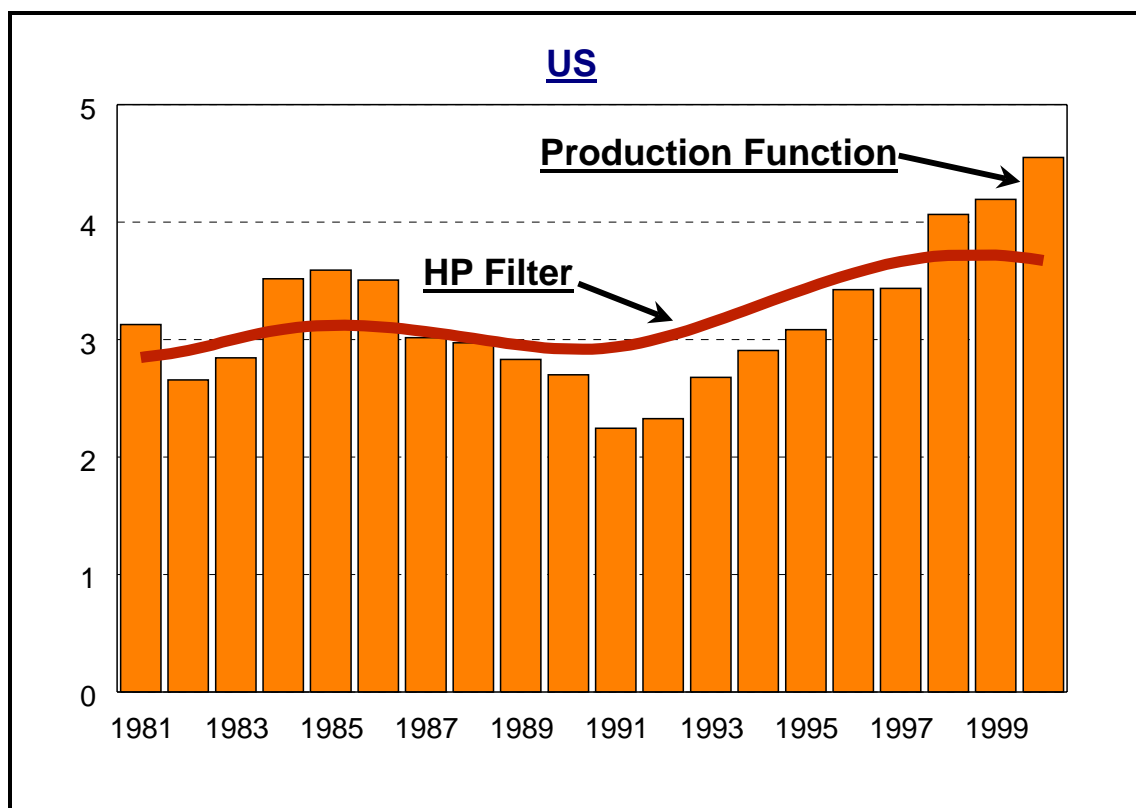
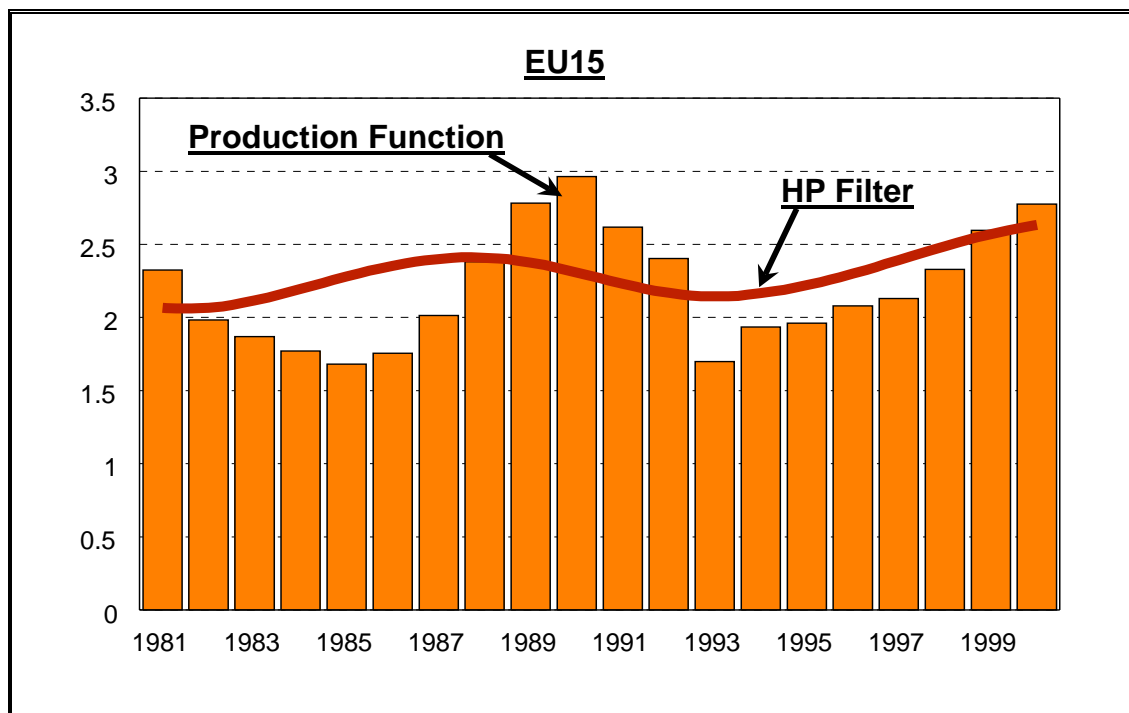


TABLE 6 : POTENTIAL OUTPUT GROWTH RATES
(COMPARISON OF ESTIMATES PRODUCED USING BOTH THE PRODUCTION FUNCTION AND HP FILTER APPROACHES*)

	EU15**		US	
	PRODUCTION FUNCTION METHOD	HP FILTER METHOD	PRODUCTION FUNCTION METHOD	HP FILTER METHOD
1981	2.3	2.1	3.1	2.8
1985	1.7	2.3	3.6	3.1
1990	3.0	2.3	2.7	2.9
1995	2.0	2.2	3.1	3.4
2000	2.8	2.6	4.6	3.7

PERIOD AVERAGES

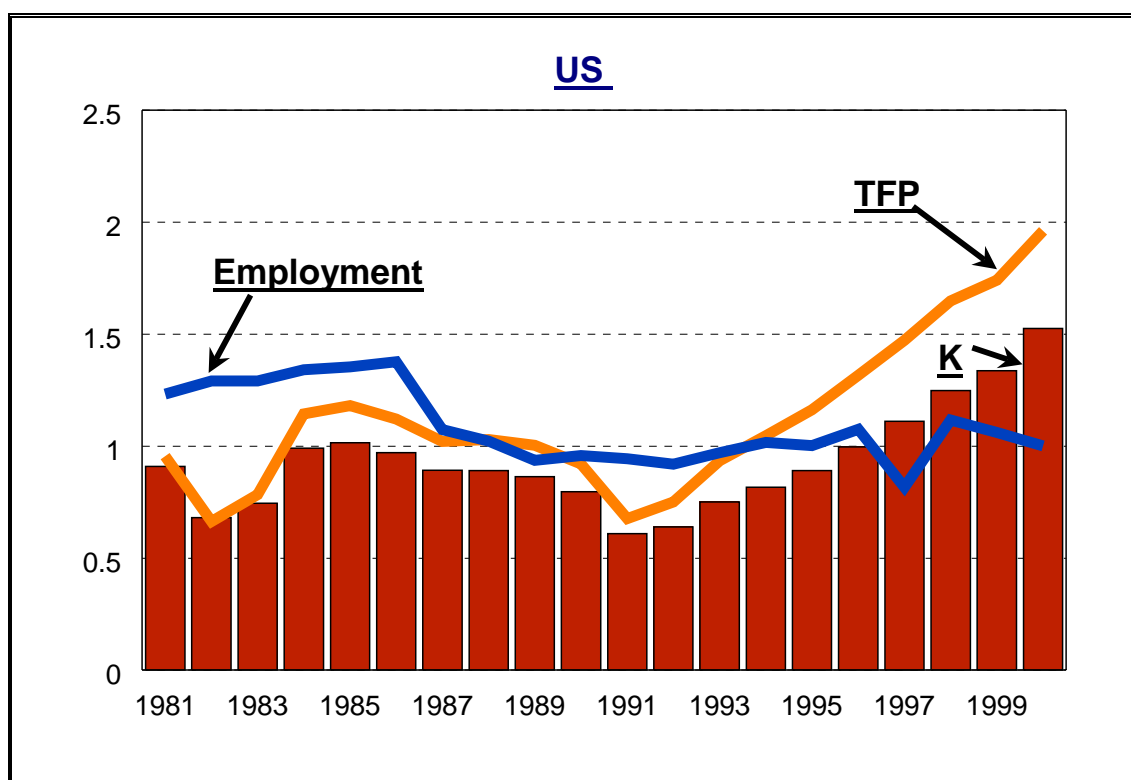
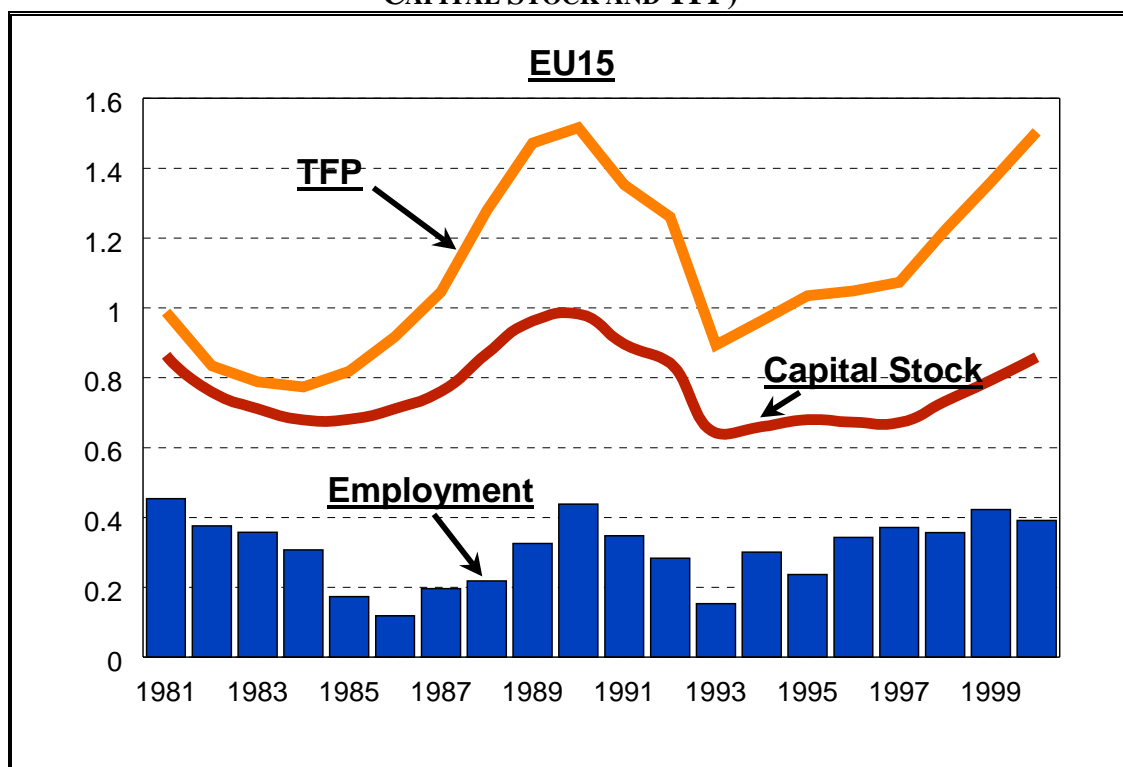
	EU15**		US	
	PRODUCTION FUNCTION METHOD	HP FILTER METHOD	PRODUCTION FUNCTION METHOD	HP FILTER METHOD
1981-2000	2.2	2.3	3.2	3.2
1981-1990	2.2	2.3	3.1	3.0
1991-1995	2.1	2.2	2.6	3.2
1996-2000***	2.4 (2.7)	2.5 (2.6)	3.9 (4.4)	3.7 (3.6)

*IT IS MORE ACCURATE TO DESCRIBE THE GROWTH RATES PRODUCED BY THE HP FILTER APPROACH AS TREND AS OPPOSED TO POTENTIAL GROWTH RATES.

** CALCULATED USING AN EU15 AGGREGATED SERIES RATHER THAN AS A WEIGHTED AVERAGE OF THE 15 COUNTRIES. AN AGGREGATION BIAS IS NOT EVIDENT SINCE THE WEIGHTED AVERAGE FIGURES WERE ALSO CALCULATED AND THE FIGURES WERE EITHER IDENTICAL TO, OR WERE NO MORE THAN +/- 0.1 COMPARED WITH, THE FIGURES PRODUCED USING THE AGGREGATED SERIES.

*** THE PERIOD AVERAGE FOR 1998-2002 IS GIVEN IN BRACKETS WITH THE FORECAST YEARS 2001 AND 2002 BEING TAKEN FROM THE COMMISSION SERVICES AUTUMN 2000 FORECASTS.

GRAPH 8 : POTENTIAL OUTPUT
 (% POINTS CONTRIBUTION TO GROWTH FROM EMPLOYMENT,
 CAPITAL STOCK AND TFP)



**TABLE 7 : PRODUCTION FUNCTION GENERATED POTENTIAL OUTPUT GROWTH RATES
CONTRIBUTIONS TO GROWTH FROM EMPLOYMENT, CAPITAL STOCK AND TFP**

	EU15		US	
	1995	2000	1995	2000
POTENTIAL GROWTH RATE	2.0	2.8	3.1	4.6
	CONTRIBUTIONS TO GROWTH		CONTRIBUTIONS TO GROWTH	
LABOUR	0.2	0.4	1.0	1.0
CAPITAL	0.7	0.9	0.9	1.5
TFP	1.1	1.5	1.2	2.1
(LABOUR PRODUCTIVITY)*	(1.8)	(2.4)	(2.1)	(3.6)

PERIOD AVERAGES

	EU15		US	
	1991-1995	1996-2000	1991-1995	1996-2000
POTENTIAL GROWTH RATE	2.1	2.4	2.6	3.9
	CONTRIBUTIONS TO GROWTH		CONTRIBUTIONS TO GROWTH	
LABOUR	0.3	0.4	1.0	1.0
CAPITAL	0.7	0.7	0.7	1.2
TFP	1.1	1.3	0.9	1.7
(LABOUR PRODUCTIVITY)*	(1.8)	(2.0)	(1.6)	(2.9)

* LABOUR PRODUCTIVITY IS DEFINED SIMPLY AS THE POTENTIAL GROWTH RATE LESS LABOUR'S CONTRIBUTION

2.2 : THE VINTAGE APPROACH : AN OPERATIONAL ASSESSMENT

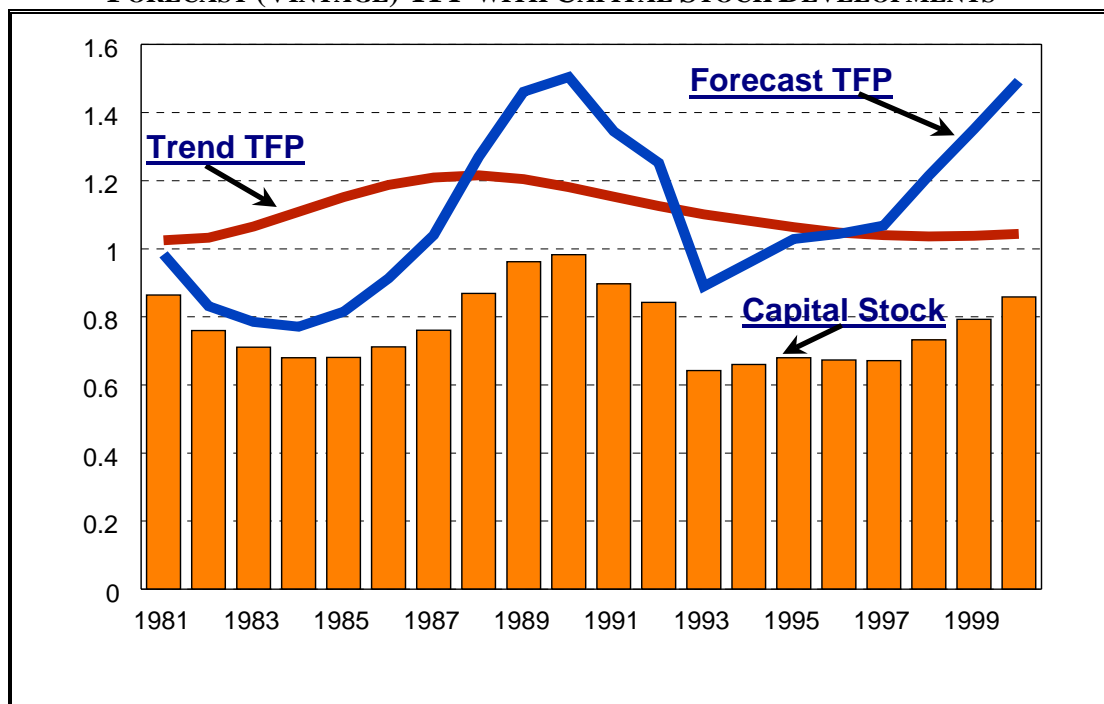
In this paper a strong case is put forward for the use of the vintage method for calculating trend TFP as opposed to using a HP filtered Solow Residual as a proxy for trend TFP. This section looks firstly at the implications of choosing the vintage method in terms of the potential output estimates produced as well as the large uncertainties involved in modelling TFP and secondly addresses the issue of whether the vintage method may suffer from an excessive procyclical bias.

VINTAGE METHOD : IMPLICATIONS FOR THE POTENTIAL GROWTH ESTIMATES :

The Production Function approach used in this paper differs from the often "hybrid" methodologies used in other international organisations, such as the OECD, which resort, to a greater extent, to the use of HP filtered inputs within an overall PF framework. One very important area where this "hybrid" approach is often used is in the crucial area of the modelling of TFP. As explained earlier, the driving force behind the present paper's approach is the desire to restrict the use of HP filtered inputs, especially when a robust economic based alternative exists. Due to the difficulty in extracting the trend TFP component from the Solow Residual series it is understandable for analysts to use a HP filtered TFP series in their production function approaches. These "hybrid" methods have the advantage of simplicity but the disadvantage of not sufficiently differentiating the HP and PF approaches as well as not providing any economically meaningful link between capital accumulation and productivity developments. The vintage approach described in Section 1 is one possible way to make this link but readers must be made aware of the uncertainties attached to all TFP estimates.

Graph 9 shows the implications for TFP trends of the decision to utilise a HP filtered trend TFP series or an economically generated estimate using the vintage approach. For example for the year 2000, TFP using the vintage method would be $\frac{1}{2}$ a % point higher compared with the estimate using the HP filter. Graph 10 and Table 8 go on to look at how these highly divergent views concerning TFP would impact on the overall growth estimates and show that in the case of 2000 that, using a HP filtered TFP series, the overall potential growth figure for the EU would be $2\frac{1}{4}\%$ whereas with the vintage method one would get a figure of $2\frac{3}{4}\%$. Given that $2\frac{1}{4}\%$ was the average growth figure experienced in the EU over the period 1980-1995, if one uses a HP filtered TFP series one is left therefore with the impression that nothing has changed in the Community in the second half of the 1990's in terms of trend growth. Alternatively, if one adopts the vintage approach there may be grounds for believing that there may have been a structural break of some sort, linked perhaps to emerging "new economy" influences on growth, at least in some of the Member States. This issue will be discussed in detail in section 3.

GRAPH 9 : MODELLING TFP IN THE EU15
- COMPARISON OF GROWTH RATES OF TREND (HP FILTER) /
FORECAST (VINTAGE) TFP WITH CAPITAL STOCK DEVELOPMENTS -



GRAPH 10 : DEGREE OF POTENTIAL GROWTH UNCERTAINTY IN THE EU15
- COMPARISON OF POTENTIAL GROWTH RATES USING
TREND (HP FILTER) V FORECAST (VINTAGE) TFP -

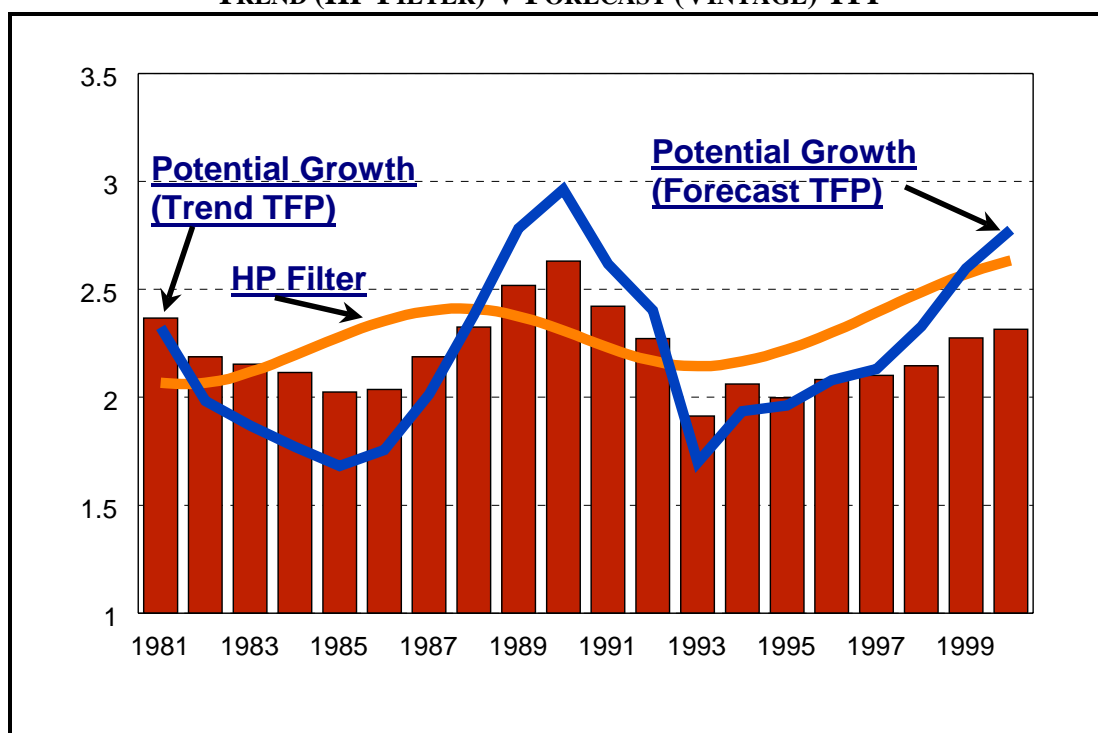


TABLE 8 : POTENTIAL OUTPUT GROWTH RATE IN 2000
(CONTRIBUTIONS TO GROWTH USING VINTAGE + HP FILTERED TREND TFP)

	EU15	
	2000 (HP FILTERED TREND TFP)	2000 (VINTAGE TREND TFP)
POTENTIAL GROWTH RATE	2.3	2.8
CONTRIBUTIONS TO GROWTH		
LABOUR	0.4	0.4
CAPITAL	0.9	0.9
TFP	1.0	1.5

VINTAGE METHOD : DOES IT INTRODUCE A PROCYCLICAL ESTIMATION BIAS

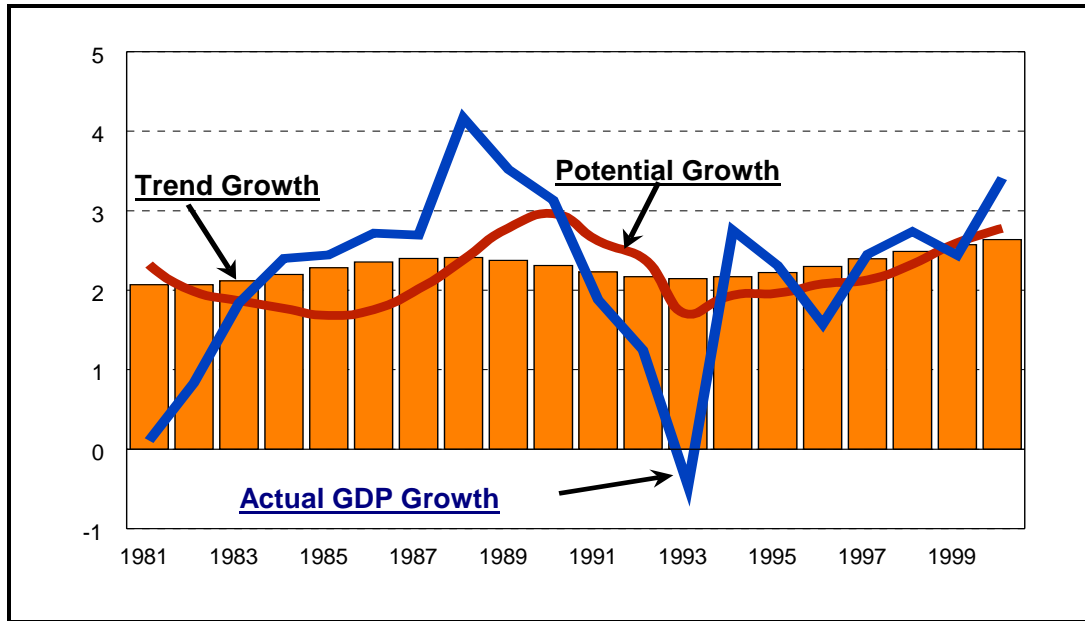
VINTAGE METHOD AND THE PRO-CYCLICALITY OF POTENTIAL OUTPUT : While all trend extraction methods invariably suffer from a procyclical bias to a certain degree, it would appear that the production function estimates suffer the most in this regard. As can be seen from Graph 11, while a large part of the cycle is clearly removed, nevertheless the potential output estimates based on a production function are typically somewhat more pro-cyclical compared to those of a HP filter with a smoothing parameter set equal to 100. The explanation for this pro-cyclicality is straightforward, linked as it is to the procyclical nature of investment and the capital stock. In addition, allowing for embodiment effects further strengthens these effects. In this context, it can be shown that the elasticity of potential output with respect to capital is given by:

$$(12) \quad \frac{\Delta y_{pot}}{\Delta k} = (1 - \alpha + \beta * agem)$$

As can be seen from equation (12), by using the vintage approach you increase the effect of capital on growth substantially since the capital stock (k) has both a capacity and an efficiency (i.e. embodiment) impact on potential output. Without embodiment effects, the elasticity of potential output with respect to capital is equal to 1 minus the wage share, which is equal to about 0.35 in Europe. However, improvements in efficiency more than doubles this output elasticity to between 0.7-0.9 since in addition to the normal capacity impact one must now add an embodiment effect of between 0.3 to 0.5. It should be underlined that while a more than doubling of the impact of capital on output may appear high, it is not excessive compared with other methods, such as for example the «Capital Stock » method of generating potential output where the (k) coefficient is set equal to 1. Finally, as suggested by equation (12) the output elasticity of capital can vary over time since it depends on the age of

the capital stock (i.e. agem). For example, with a relatively antiquated capital stock, capital formation has a larger efficiency enhancing effect, with embodiment effects from an already modern capital stock being significantly smaller²¹.

GRAPH 11 : A LOT OF THE CYCLE HAS BEEN REMOVED
- EU15 : POTENTIAL (PF), TREND (HP FILTER)
AND ACTUAL GDP GROWTH RATES -



CORRECTING THE BIAS BY USING A CAPACITY UTILISATION VARIABLE : The procyclicality of the trend TFP component using the vintage method referred to above is shown clearly in graph 5 in Section 1 giving the trend TFP and capital stock series²², showing as they do that the capital stock and trend TFP lines are roughly proportional. Consequently, it is evident that the vintage approach is extracting from the Solow Residual a trend TFP growth component which is roughly equivalent to the growth rate of capital and since capital is a pro-cyclical variable, TFP inevitably also suffers in the same way. However, since it is widely accepted that K should not be de-trended, since it is the only way to accurately represent the effect of capital accumulation on growth, the only possibility is to see whether the trend TFP figures can be adjusted for this pro-cyclical bias. The following paragraphs look at one possible way to correct for this bias by looking at the effects of including a capacity utilisation term in the estimation equation.

With regard to the use of a capacity utilisation variable to correct for the procyclicality of the vintage method, it needs to be pointed out that the production

²¹ **Explanation for cross-country differences in capital stock / TFP elasticities** : There are only 3 possible sources of cross country differences in such elasticities. Firstly, differences in the growth rate of the capital stock itself. Secondly, differences in the estimated coefficients for AGEM (these coefficients are relatively small with Table 5 in Section 1.3.3 showing that they range from .002 in Denmark to .07 in Greece) and, finally, the age of the capital stock itself. This last factor can have a big effect on the way K impacts on TFP. If, for example, investment has been low for some time a sudden increase could boost TFP very quickly.

²² In terms of a comparison of the variability / cyclicity of all three components (labour, K and TFP) of potential growth, between the US and the EU, there is less cyclicity in the US component series (TFP was the most pro-cyclical) compared with the EU and that for both geographical regions labour potential shows the smallest degree of variability and TFP the highest.

function method employed in this paper, in general, ignores capacity utilisation (CU). There is a sound theoretical reason for ignoring CU since a bias problem would only exist if there is a strong correlation (either positive or negative) between CU and the age of the capital stock (*agem*), with, for example, a negative correlation implying that an increase in CU would lead to an increase in investment and a fall in *agem*. Since *agem* is a slow moving variable, whereas CU is highly cyclical, a low correlation would therefore be expected a priori. This small correlation would translate into either a small downward or upward bias for *agem* which in turn would also reflect itself in trend TFP and potential growth.

In assessing the case for including capacity utilisation data, survey data for capacity utilisation in industry²³ for a number of EU member states and for the EU15 as a whole (see graph 12) were used in the vintage regression method, with the expectation of finding that the coefficient on the *agem* variable in the equation would be firstly negative and secondly less negative if the CU variable was also included in the regression. However, the results were surprising on two fronts. Firstly, the correlation between CU and *agem* appears in general to be slightly positive, not negative as had been expected²⁴. Secondly, if the CU variable is included in the regression, the coefficient on *agem* often becomes more negative (note : if the correlation had been negative the coefficient would have become less negative), implying that the embodiment effect becomes even stronger and that consequently the potential output series is even more closely linked with the cycle than before (i.e. for the four EU member states which were examined, trend TFP followed developments in *k* even more closely than had been the case when CU was excluded from the equation and consequently TFP has an even greater procyclical bias - this however was not the case with the EU15 aggregated figures).

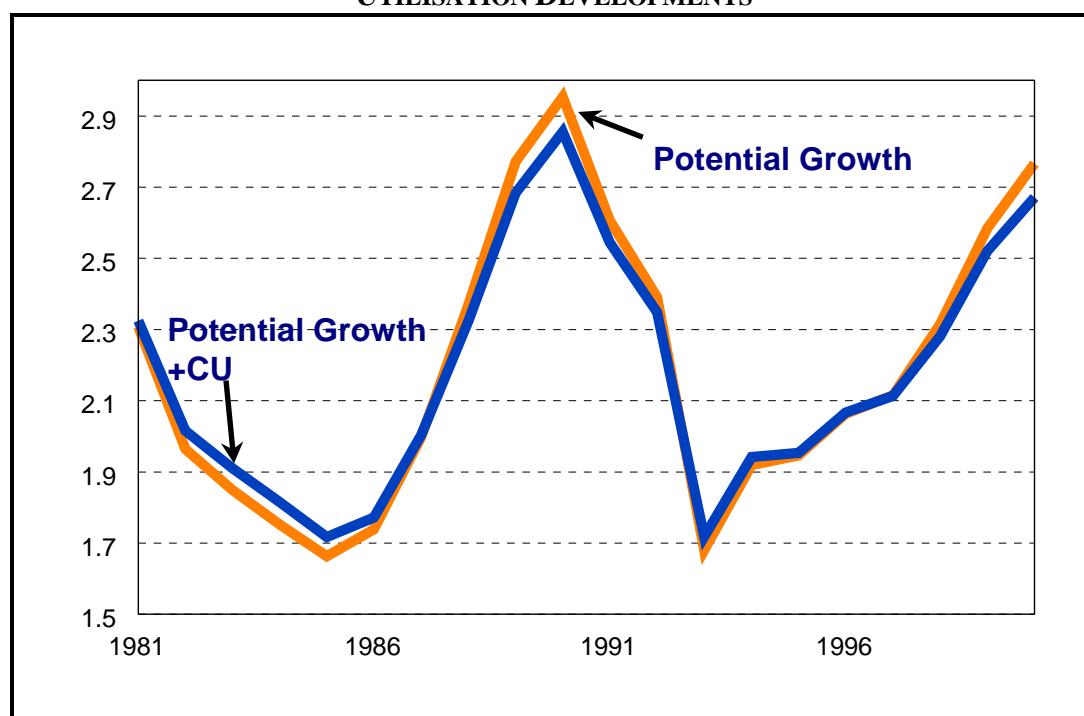
While the results may have been somewhat surprising in that they were the opposite of the authors a priori expectations, it should be reiterated that given the fact that any correlation, be it negative or positive, is always likely to be small, the resultant bias will also be small and therefore one would need very robust capacity utilisation data to be absolutely certain that one was getting even the sign of any potential bias correct. Consequently, on the basis of the analysis of the EU survey data at least, there does not appear to be a strong case for including an adjustment to the Solow Residual to allow for changes in capacity utilisation. In addition, as explained above if a capacity utilisation term was included you would often end up with even slightly higher potential rates of growth. However, despite these results, it is important for future research to examine the possibility of using other indicators of capacity utilisation such as energy consumption or the working time of workers and to also examine the possibility of whether the relationship between capacity utilisation and the age of the capital stock is different in the US compared with the EU. For the reasons spelt out above, the authors are not however particularly hopeful of getting good results with the alternative capacity utilisation indicators. The only other route would be to use model simulation exercises, with technology shocks being used to estimate the possible bias involved. The model would need to be simulated, excluding embodiment effects, which at the moment are included in the calculations. Consequently the difference between the two experiments (i.e. between excluding and

²³ A capacity utilisation term for the whole economy, which of course would be the ideal variable to use, is unfortunately not available at the EU15 level.

²⁴ Of course a positive correlation is also possible since an increase in capacity utilisation could have the effect of decreasing investment and consequently increasing the mean age of the capital stock.

including embodiment effects) would represent the estimate of the bias which would then be applied to the final potential growth figures in order to adjust them for any pro-cyclical bias which existed.

GRAPH 12: EU15 : POTENTIAL GROWTH RATE CORRECTED FOR CAPACITY UTILISATION DEVELOPMENTS*



* Rate of Capacity Utilisation in Manufacturing (Source : Commission Services)

POLICY MAKERS MAY HAVE TO LIVE WITH THIS PROCYCLICAL BIAS : From the evidence presented above it would appear that policy makers will have, for the foreseeable future, to live with the possibility that a business cycle bias may exist with the vintage method. While this potential pro-cyclical bias is, at the moment, unavoidable due to the effect of using an unsmoothed capital stock series, it is important to stress that the crucial issue is determining whether part of the so-called bias may in fact be embodiment effects emanating from the investment which has taken place. In other words, as shown earlier, if the increase registered in potential output is not due to the absence of a capacity utilisation variable (with in the case of the EU15 the latter variable adding in fact at most 0.1 to the figures in the late 1990's) then one must ask the question whether the increase in potential growth in the EU to a growth rate of $2\frac{3}{4}\%$ in 2000 is really a procyclical bias or could it perhaps be indicating a structural break in the long run growth potential of the EU. This is the fundamental issue which is discussed in detail in sections 3 and 4 of this paper.

2.3 OUTPUT GAP DEVELOPMENTS 1981-2000 + POLICY APPLICATIONS

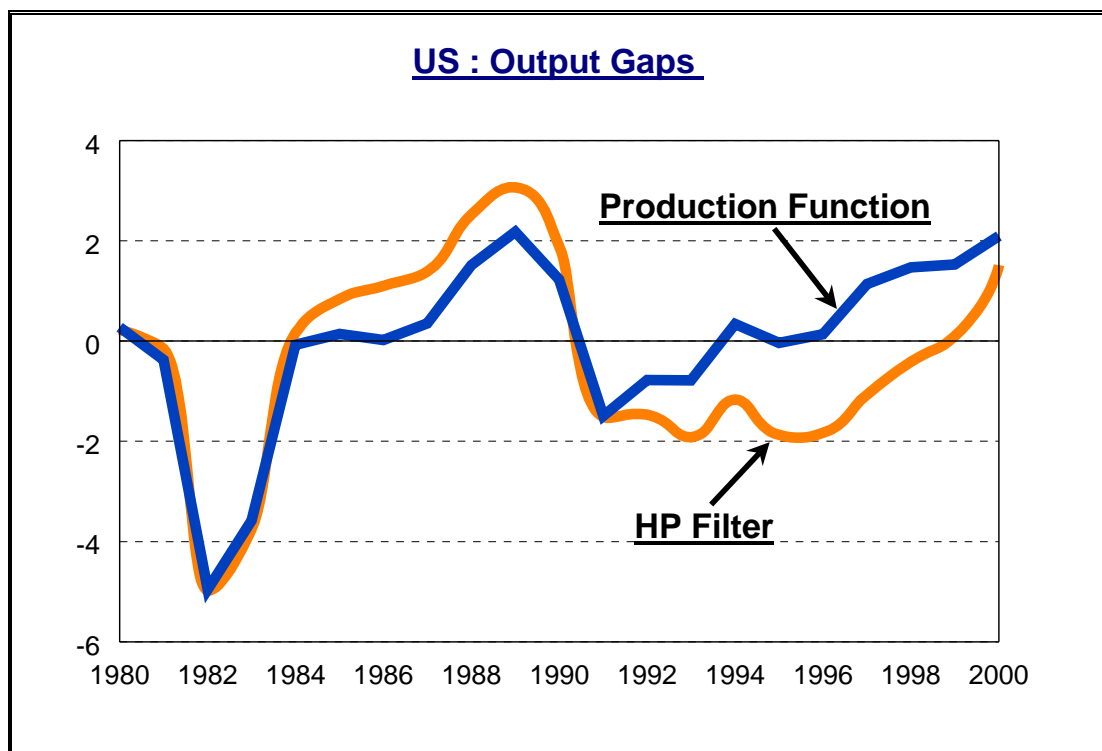
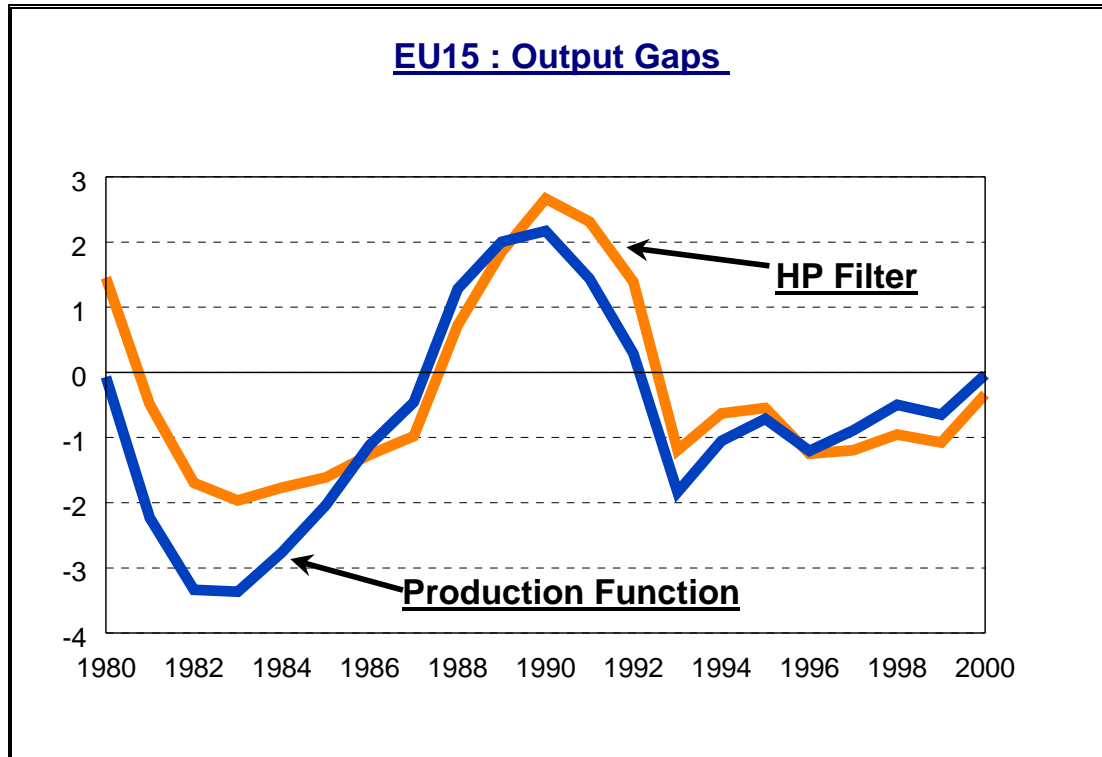
ARE THERE SIGNIFICANT DIFFERENCES BETWEEN THE HP AND PF APPROACHES IN TERMS OF OUTPUT GAP CALCULATIONS²⁵ : As graph 13 for the EU and the US shows, the differences between the output gaps produced by the two methods are not that dramatic for the EU and the US for the year 2000 but the methods have produced sizeable discrepancies at particular points in time over the last 20 years. In the case of the US, divergences between the two methods really started to manifest themselves in the 1990's, with the production function method indicating a much more rapid closing of the output gap, with a positive gap in fact being shown since around 1994. In the case of the HP filter it suggested that the negative output gap persisted up until 1999 but both methods are now pointing to a positive gap of about 1 ½ -2% of GDP. For the EU, in contrast, both methods have produced output gaps for the 1990's which are generally of the same order of magnitude. With the production function approach, the negative output gaps in the early to mid 1990's tend to be slightly larger, compared to those produced by the H-P filter, with these differences being traced to the different “filtering” philosophies behind the two methods. However, as in the case of the US, the PF method indicates a more rapid closing of the output gap in the second half of the 1990's in the EU.

TABLE 9 : OUTPUT GAPS
(COMPARISON OF ESTIMATES PRODUCED USING BOTH THE PRODUCTION
FUNCTION AND HP FILTER APPROACHES)

	EU15		US	
	PRODUCTION FUNCTION METHOD	HP FILTER METHOD	PRODUCTION FUNCTION METHOD	HP FILTER METHOD
1980	-0.1	1.5	0.3	0.2
1985	-2.0	-1.6	0.1	0.8
1990	2.2	2.7	1.2	1.9
1995	-0.7	-0.5	0.0	-1.9
2000	0.0	-0.3	2.1	1.5

²⁵ The output gap measures whether the economy is under or overheating and consequently is a concept which is widely used for assessing the stance of fiscal and monetary policies. A priori one would expect that, relative to the HP filter, the PF method would produce larger negative output gaps in downturns and smaller positive output gaps in upturns. However, such generalisations need to be checked against the specific country data, with the empirical supporting evidence being stronger in the case of downturns than in upturns.

GRAPH 13 : EU15 AND US OUTPUT GAPS



PRODUCTION FUNCTION GENERATED OUTPUT GAPS : DECOMPOSITION OF OUTPUT GAPS INTO TECHNOLOGY + UNEMPLOYMENT GAPS²⁶

Unlike the HP filter method, the production function approach also allows the total output gap to be decomposed into a number of components. The output gap, within the production function framework, essentially consists of three components, namely temporary deviations of total factor productivity from trend, excess capacity of capital and deviations of the unemployment rate from its structural level. Thus, in principle, a production function approach may provide additional information for assessing a particular cyclical episode which could be helpful in economic policy discussions. However, it should be noted that the production function approach used in this note utilises a narrower decomposition of output gaps which only permits a breakdown of the output gap into contributions from the production side of the economy (i.e. the technology gap which is simply the percentage deviation between measured and trend TFP) and from the labour market (i.e. the unemployment gap which is equal to actual unemployment less the NAIRU)²⁷. While no attempt has been made in the present note to decompose the "production" gap term into technology shocks and fluctuations in capacity utilisation, this could be a further step in any future work. The decomposition could either be achieved by statistical decomposition or by using observations on various measures of capacity utilisation. However, as the analysis regarding the vintage approach in section 2.2 made clear, it is difficult to separate temporary total factor productivity shocks from changes in capacity utilization.

As regards the decomposition of the output gaps for the US and EU15 for the period 1980-2000, from Graph 14 one can see that over the last few years, for the EU, developments in the technology gap (i.e. the output gap in a narrow sense) and the unemployment gap often tended to offset each other with neither dominating the movement in the overall production function output gap. Thus, cyclical movements in the utilisation rate of capital together with temporary productivity shocks have tended in recent years to offset the movements on the labour market side resulting in small overall changes in terms of the overall cyclical variation in GDP. In the case of the US, one sees that since the output gap was closed in the mid-1990's both the labour market and the production side appear to be operating at above their sustainable rates, with most of the latent inflationary pressures appearing to emanate from the labour market side.

²⁶ In technical form the output gap is given by:

$$y - y^p = \alpha(nairu - lur) + (1 - \alpha)uc + tfp^r$$

with $(nairu - lur)$ equal to the unemployment gap and with $(1 - \alpha)uc + tfp^r$ acting as a proxy for the technology gap. [tfp^r = the gap between TFP and TFP^T]

²⁷ The labour market component is in fact composed of the unemployment gap term and what is in effect a participation rate gap (i.e. the gap between the actual participation rate and the HP filtered participation rate).

**TABLE 10 : OUTPUT GAPS PRODUCED USING THE PRODUCTION
FUNCTION APPROACH***
**CONTRIBUTIONS TO OUTPUT GAP FROM LABOUR MARKET AND TECHNOLOGY
DEVELOPMENTS**

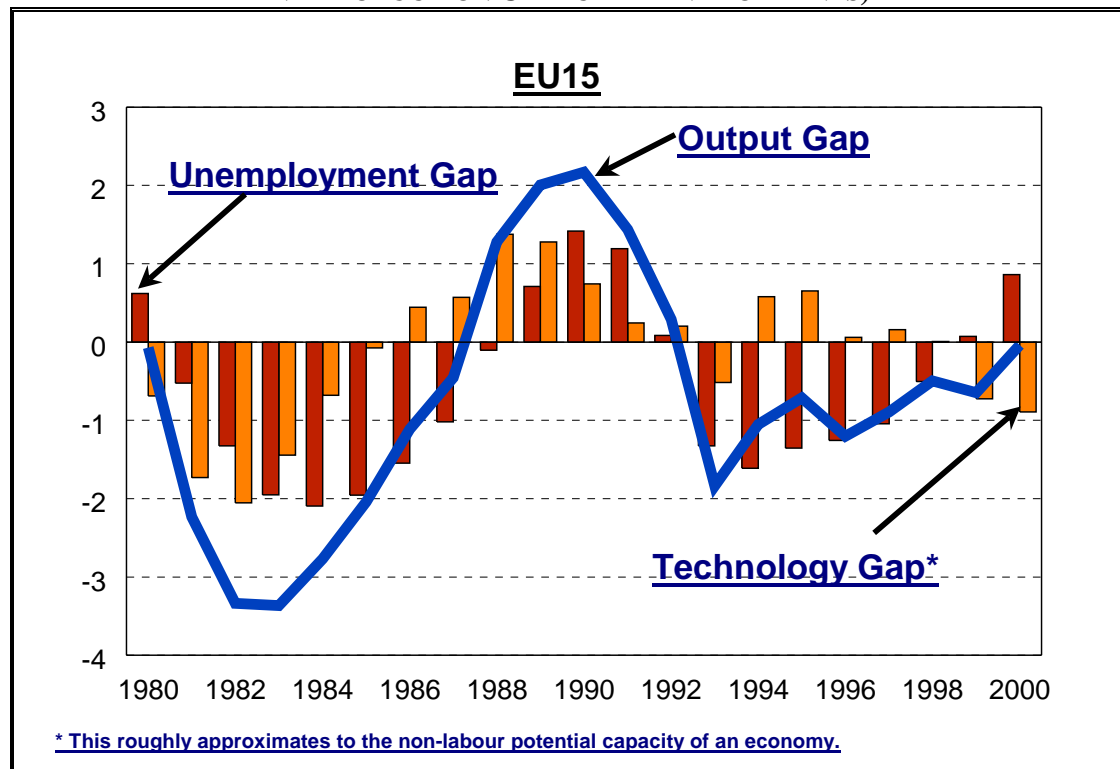
	OUTPUT GAP	UNEMPLOYMENT GAP**	TECHNOLOGY GAP***
	<u>1995</u>		
EU15	-0.7	-1.4	0.7
US	0.0	0.1	-0.1
	<u>2000</u>		
EU15	0.0	0.9	-0.9
US	2.1	1.3	0.8

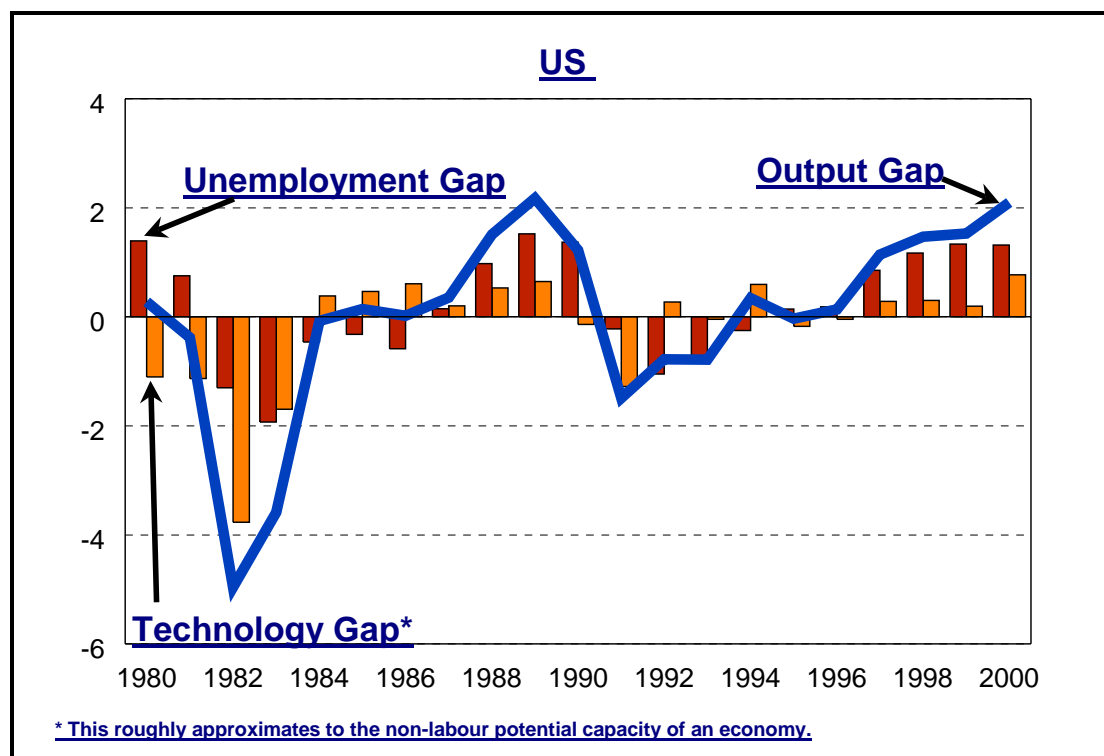
* Positive Gaps can be interpreted as indicating an over-utilisation of available resources (i.e. an inflation risk).

** The unemployment gap also includes an adjustment for the gap between the actual and the trend participation rate.

*** The technology gap is made up of two components : an endogenous part which is an efficiency index for the fixed capital stock which is driven by the mean age of the capital stock + an exogenous component which is labour augmenting technical progress.

**GRAPH 14 : OUTPUT GAPS - PF APPROACH
(CONTRIBUTIONS TO OUTPUT GAP FROM LABOUR MARKET
AND PRODUCTION CAPACITY DEVELOPMENTS)**





OUTPUT GAP POLICY APPLICATIONS : INFLATION AND BUDGETARY SURVEILLANCE

This sub-section looks at the main policy applications of the derived output gap series where the well known short run biases associated with the PF and HP estimation methods may need to be taken into account in the interpretation of developments over a 1-2 year time horizon. Such methodological biases may distort the output gap estimates and consequently could have implications for the carrying out of inflation and budgetary surveillance exercises. Since this is essentially a methodological issue, the analysis below is carried out using the output gaps for the EU only, with the difficulties in terms of interpreting changes in the "gaps" over time also being alluded to (**note:** these difficulties are not, of course, confined to the previously mentioned methodologically induced biases but also relate to issues such as do changes in the gap reflect supply or demand side shocks etc). These HP and PF "gaps" are compared in terms of their inflation tracking performance as well as in terms of the differences which both methods produce for structural budget balances.

EU INFLATION SURVEILLANCE

HOW WELL DO OUTPUT GAPS EXPLAIN PAST CHANGES IN PRICE INFLATION ? At the outset it is important to underline that it is extremely difficult to empirically assess the absolute and relative quality of the output gaps produced by either of the two methods since trends in the "gaps" are driven by a complex mixture of both supply and demand side factors/shocks. While it is not excluded that changes in output gaps and changes in inflation go hand in hand, it is clear that symmetric movements of both variables cannot be expected, a priori. In fact, the output gap can be positive not only because demand drives the actual unemployment rate below the natural rate and/or

because capacity utilization is above average but also because of a temporary, negative, technology shock. Therefore, the relationship between the output gap and changes in inflation is ambiguous, with in fact the poor, on average, inflation tracking ability of the output gap being largely due to this inability to decipher whether changes in the gap are being driven by demand or supply side influences. Because of this inherent weakness, it is generally accepted that the relationship between unemployment gaps and changes in wage inflation is much stronger than that between output gaps and changes in price inflation.

However, despite the widely accepted remarks contained in the previous paragraph, output gap analysis nevertheless remains very important in the policy making framework since assessing the usefulness of the output gap concept solely in terms of its inflation tracking abilities is not appropriate. Indeed, if that was the sole determinant it is clear that other methods for calculating output gaps, such as the use of Kalman Filtering techniques, would produce substantially better inflation tracking properties. Such a restricted perspective regarding the usefulness of the concept is thankfully not widely shared. Other measuring rods must be adopted to give a more complete evaluation of the concept, such as the information content it provides in terms of medium term growth prospects or its ability to shed some light as to the supply or demand side source of changes in the gap over time. In this regard, it may be perhaps useful to recall that the empirical success of the Taylor rule approach to monetary policy analysis emanates in large part from its inclusion of both the output gap and inflation variables in its analytical framework. Placing the emphasis on both indicators helps in determining the source of any shocks, with, by way of example, changes in the output gap without any corresponding movement in inflation perhaps being indicative of changes on the supply side of an economy.

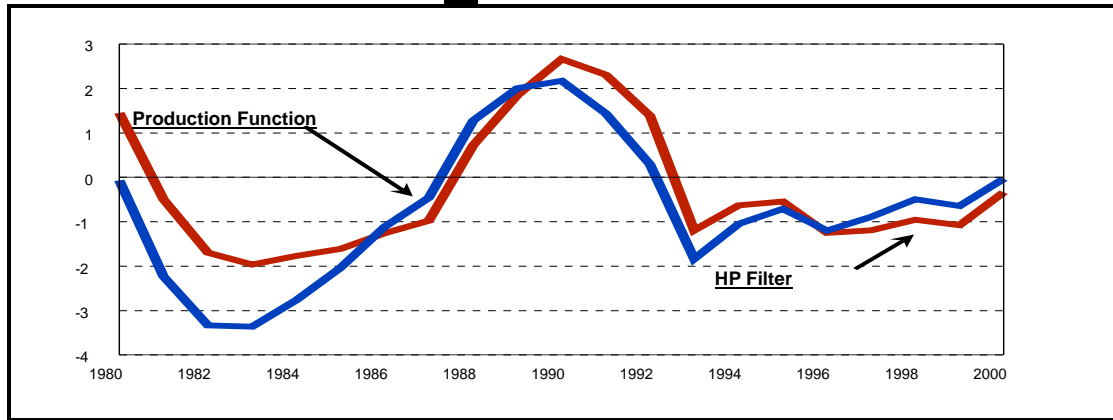
With regard to the output gaps produced in this paper, it is not surprising to find, given the comments in the previous two paragraphs, that output gaps explain only a small proportion of the change in price inflation over the 1990's. Despite the apparently good tracking performance, indicated in Graph 15, between output gaps in the EU and changes in price inflation, simple regressions between the calculated output gaps and the change in inflation show clearly that a relatively small percentage (roughly 30-35%) of the price change in the EU15 can be explained by movements in the output gap.

DOES THE PRODUCTION FUNCTION METHOD PRODUCE BETTER INFLATION TRACKING RESULTS THAN THE H-P FILTER ?

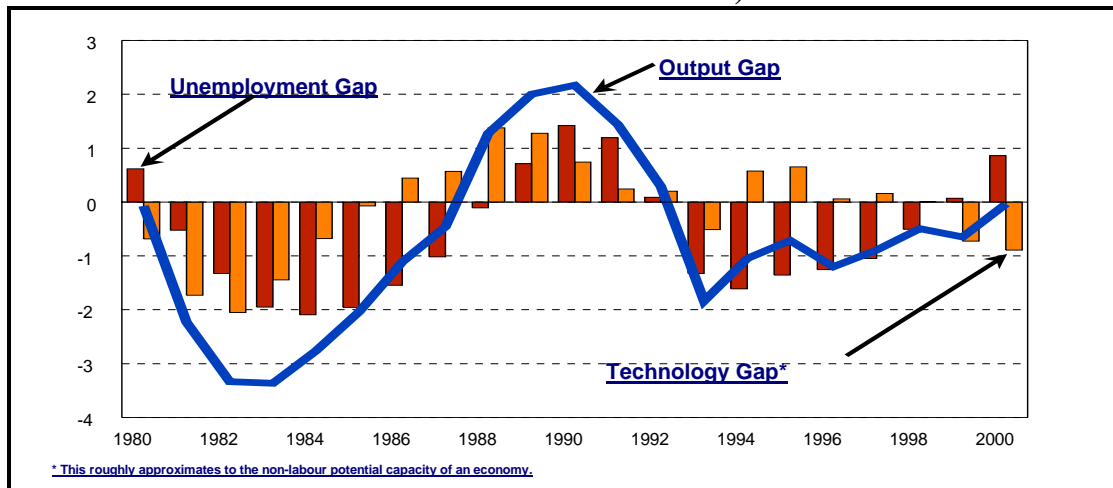
The essential question to be addressed here is whether economic, as opposed to statistical, estimates of potential output can improve on the price inflation tracking performance of the resultant output gap calculations. As explained above both sets of output gaps were quite poor in tracking past changes in price inflation and, with regard to the respective performance of the two competing methods, there would appear to be no essential difference in the information content of the H-P filtered output gaps and the corresponding gaps produced using the production function approach. Again, as with the potential output results, the conclusion would appear to be that both methods have their advantages, with very little to choose between them in terms of the information content, for policy evaluation purposes, of the resultant output gaps.

GRAPH 15 : EU15
OUTPUT GAPS AND THE CHANGE IN PRICE INFLATION

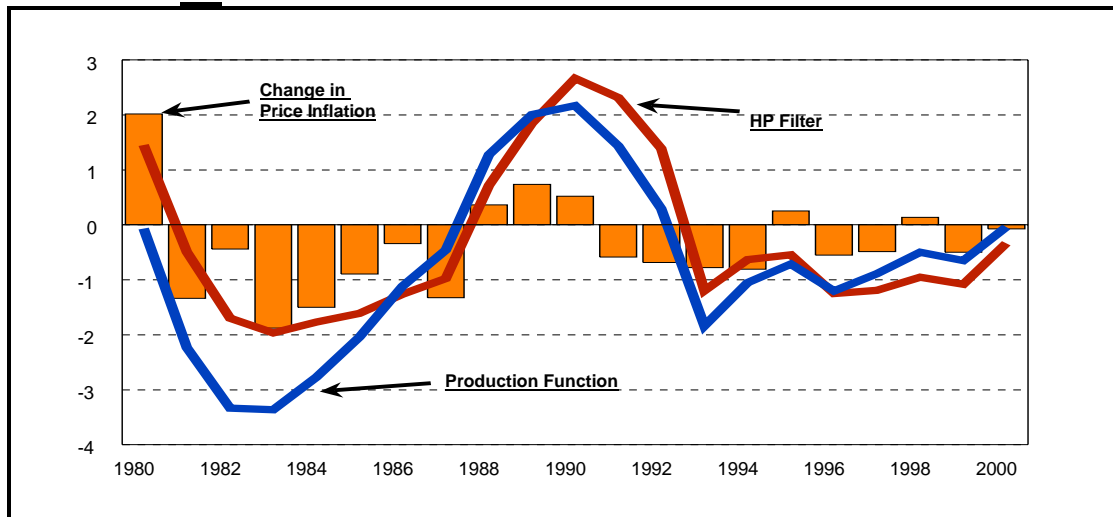
A: OUTPUT GAPS



B: OUTPUT GAPS - PF APPROACH
(CONTRIBUTIONS TO OUTPUT GAP FROM LABOUR MARKET AND PRODUCTION
CAPACITY DEVELOPMENTS)



C : OUTPUT GAPS AND THE CHANGE IN PRICE INFLATION



EU BUDGETARY SURVEILLANCE : OUTPUT GAPS AND THEIR EFFECT ON STRUCTURAL BUDGET BALANCES

In this sub-section the method used by the EC Commission services to cyclically correct actual budget balances is examined to see whether there would be significant differences if one were to use the PF as opposed to the HP filtered generated output gaps in the cyclical adjustment method. At the moment the cyclically adjusted budget balances are produced using only the output gaps from the HP filter method, with the effect of these "gaps" in terms of the public finances being estimated using the appropriate budgetary elasticities. The underlying or structural balance position is then produced by taking the actual budget balances and "correcting" them for the calculated cyclical effects.

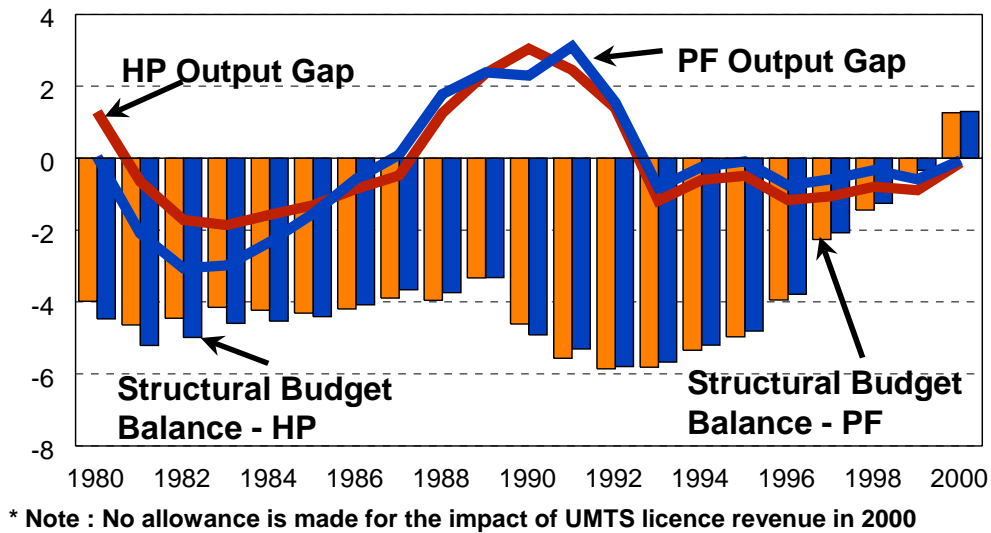
At the outset it is important to state clearly the limited nature of the present analysis. Only one specific aspect of this complex area is examined, namely do the inherent biases associated with both the HP and PF methods significantly alter the final structural balances produced at different stages of the cycle. These biases have already been referred to and essentially reflect the fact that the HP filter produces a smoother series over the cycle since in terms of leads and lags the HP filter is a symmetric or two-sided filter which takes future as well as past information into account. The PF method on the other hand produces a less regular potential output series since it only takes past information into account. These differences in the underlying methodologies could have implications for the size of the output gaps produced at different stages of the cycle, with the PF method perhaps leading to some over-estimation of potential output in the expansion phase of the cycle and with the HP filter being perhaps biased downwards in a recession because it takes the downturn somewhat into account.

While a priori one would expect the above two biases to have some effects, it is very difficult to generalise as to the impact of these biases when one applies both methods to specific country examples. This difficulty appears to arise in the main from the fact that the starting point for the two methods, in terms of the existing output gap in levels, can be very different for the two methods depending on where the HP filter has been started from and the extent of the initial gaps²⁸. However, despite this difficulty, a number of comments are still possible. The first point to note is that if the differences in the output gaps produced by both methods are small then, not surprisingly, the size of any bias is also correspondingly small. This is shown clearly in Graph 16 where the output gaps and resultant cyclically adjusted budget balances are shown for the EU15. In addition, only a proportion of any differentials in the "gaps" result in changes in the structural balances since not all of the budget is cyclically sensitive.

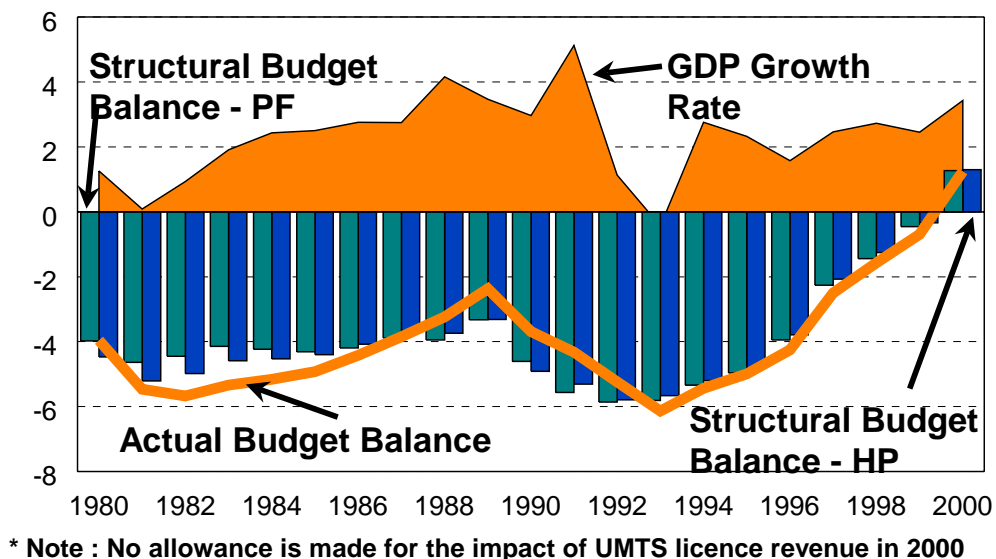
²⁸ It is not possible to adjust for these differences in starting values by, for example, making the gaps equal to zero in 1980 since in doing so one loses the property that the output gap is zero over the cycle (at least in the case of the HP filter).

GRAPH 16 : STRUCTURAL BUDGET BALANCES

EU15 : Output Gaps + Associated Structural Budget Balances*



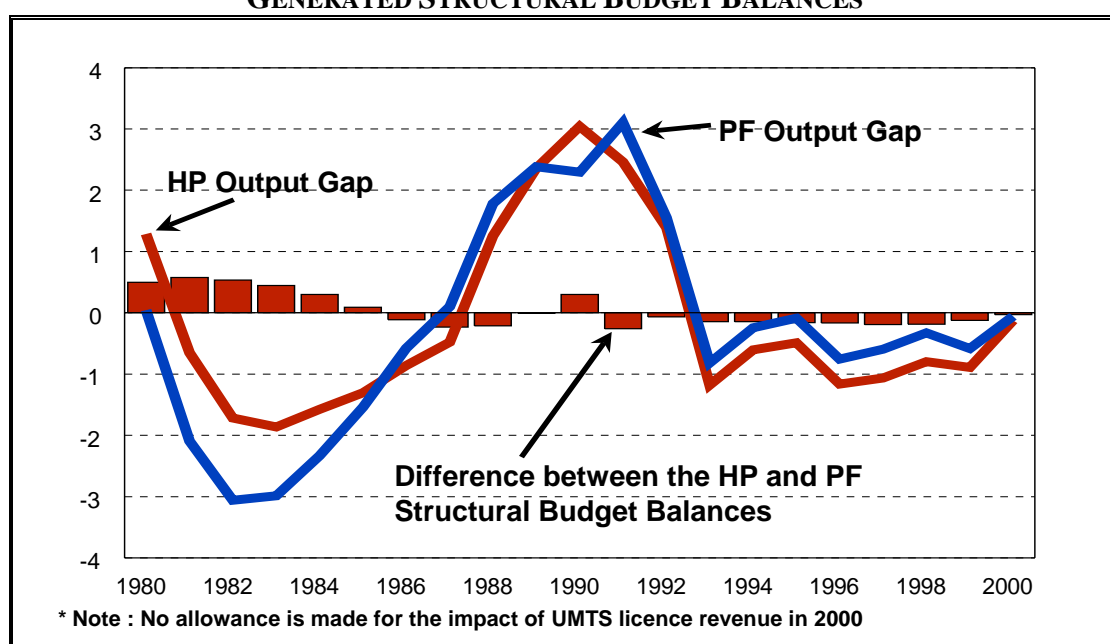
EU15 : Structural and Actual Budget Balances- Cyclical Influences*

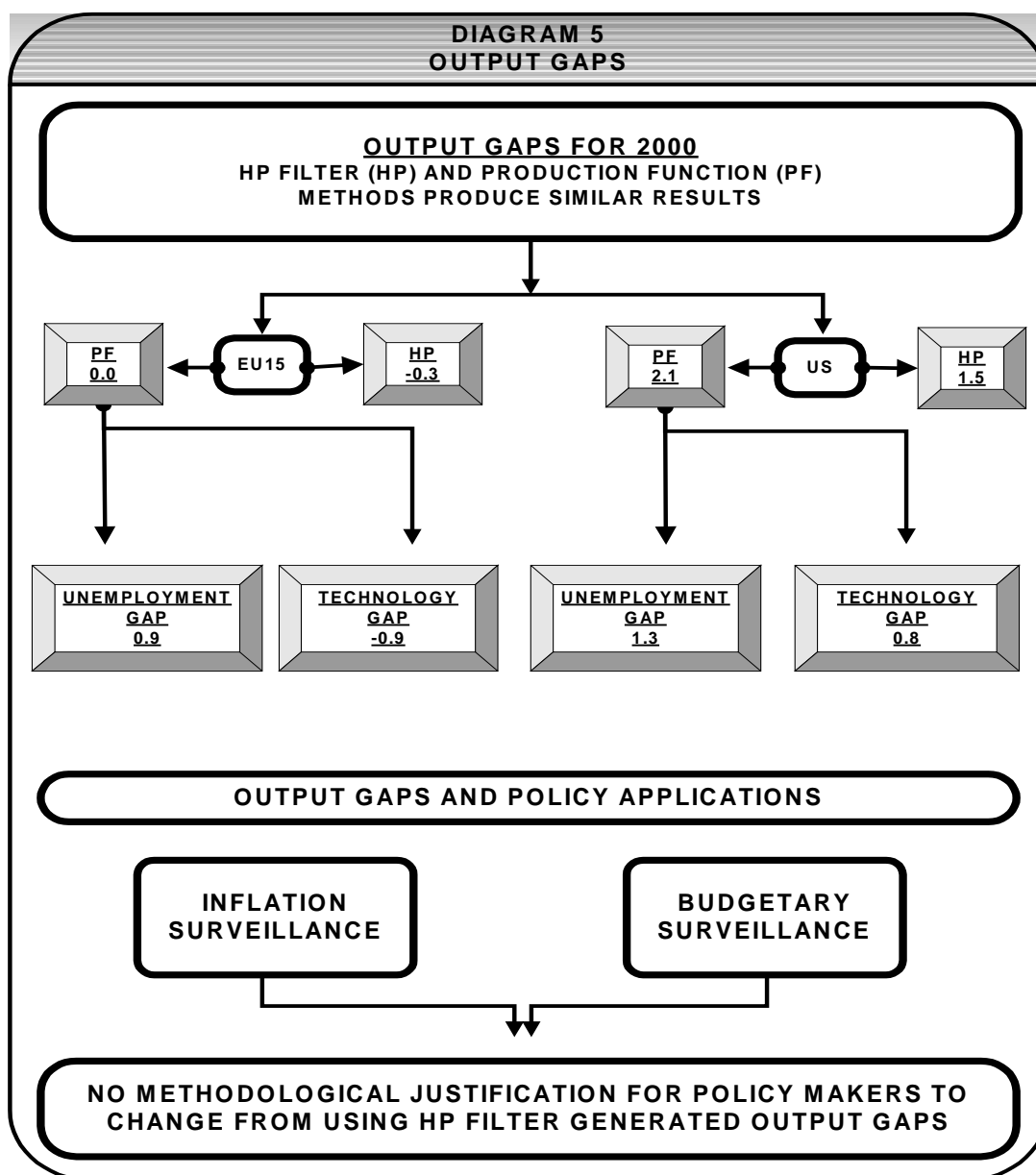


While these initial comments are fairly uncontentious, being very precise in terms of demonstrating the extent of any biases is quite difficult for the reasons outlined in the previous paragraph. It is important to be clear that we are only effectively talking about individual year biases since for both methods any individual year "gains" are compensated by "losses" at other points of the cycle. In other words both methods are broadly symmetric and consequently over the complete cycle the overall effect on structural balances is close to zero. The definition of symmetry here is different to the one referred to above in terms of leads and lags. Here symmetry over the cycle refers to the fact that both methods have a mean of zero i.e. the cyclical component sums to zero. A rough indication of the individual year biases is shown in graph 16a below, where in addition to the output gaps for both methods, the differences between the two approaches in terms of the structural budget balances produced are also given to provide an estimate of the extent of any possible biases. If one compares the results over the last 20 years one can see from the graph that the differential between the two methods was a maximum of 1/2 a percentage point for the EU15 as a whole in any given year and that over the total period from 1980 to 2000 the mean difference was close to zero.

In conclusion therefore, in the area of structural balances, it is important to stress that while methodological "biases" may be at play at certain stages of the cycle, use of one or other method does not appear to be a significant issue as evidenced by the closeness of the output gaps and the small differential in structural balances when both methods are compared. These results for the EU15 would of course equally apply to those Member States where both the budgetary elasticities were similar and where the output gaps were of an equivalent size. Consequently, on the assumption that the output gap used (i.e PF V HP) is the only input to change in the Commission services structural adjustment methodology, there would appear to be no significant **methodological** justification for a switch to using PF generated output gaps as opposed to the present practice of using HP filtered generated gaps.

**GRAPH 16A : EU15 : OUTPUT GAPS + DIFFERENCE BETWEEN THE PF AND HP
GENERATED STRUCTURAL BUDGET BALANCES***





CONCLUDING REMARKS FROM SECTION 2

From the analysis presented in sections 2.1 and 2.2 it is clear that all trend extraction methods exhibit short run fluctuations with no method guaranteeing that the trend path is correct. However, it would appear that the vintage method used in the PF approach may, by construction, be particularly prone to changes in the business cycle. As the discussion earlier underlined, this is due to the fact that the capital stock is naturally a pro-cyclical variable and since TFP is strongly influenced by capital accumulation in the vintage approach then TFP itself will also unavoidably have an element of pro-cyclicality. However, the main question is whether or not the extent of the rise in trend TFP in the late 1990's is overdone using the vintage method since it may not be adequately controlling for the effects of the business cycle. From the analysis undertaken in this section there is not much evidence to suggest that the

inclusion of a cyclical indicator such as capacity utilisation would radically alter the view that there may have been an historically significant, although small, upturn in potential growth in the EU over this recent period. While the vintage method may still suffer from a pro-cyclical bias, it appears that policy makers will have to live with this uncertainty, at least for the foreseeable future, unless researchers can come up with better capacity utilisation indicators or model based estimates of any possible bias involved.

In terms of the degree of uncertainty associated with TFP developments, one could, for example for the year 2000, get a differential in potential growth of up to half a percentage point depending on whether the HP or vintage methods are utilised to calculate trend TFP. As explained earlier, if one uses the HP approach, the late 1990's does not represent a break with the past since the long run trend growth of $2\frac{1}{4}\%$ which this approach would produce is exactly in line with the average experienced over the period 1980-1995. One gets a different view with the vintage approach which provides evidence that something significant may be happening in recent years, with trend growth rising to between $2\frac{1}{2}\%$ and $2\frac{3}{4}\%$. However, given the understandable doubts that the procyclical features of the vintage method could be playing a role, serious questions need to be answered before one could suggest that the upturn in TFP is purely structural? The stakes are high in this debate in that if the vintage view proves accurate that a structural TFP break has occurred in the EU over the second half of the 1990's, linked to ICT developments, then the EU may be experiencing something which has not happened in two decades, namely an upturn in long run productivity and overall potential growth rates. Given the need to corroborate the "vintage" story presented in this section, the final two sections of this paper will be entirely focussed on the question of whether a potential growth rate of $2\frac{3}{4}\%$ in the EU (and over 4% in the US) is both justified at the present time and sustainable over the medium to long run. Section 3 examines the evidence for a structural TFP break in the EU and US over the second half of the 1990's linked to "new economy" effects and section 4 looks at the medium to long run prospects for the EU and US economies on the basis of various "new economy" and, in the case of the EU, labour market scenarios for the period 2001-2010.

SECTION 3
"NEW" ECONOMY EFFECTS ON POTENTIAL GROWTH :
COMPARISON OF US AND EU15 PERFORMANCES

SECTION 3 : "NEW" ECONOMY EFFECTS ON POTENTIAL GROWTH : COMPARISON OF US AND EU15 PERFORMANCES²⁹

INTRODUCTION : WHERE IS THE OPTIMISM COMING FROM IN THE PRODUCTION FUNCTION METHOD : Given that the investment to GDP ratio has not yet shown a marked acceleration in the EU, although there has been an upturn over recent years, this section will address the question of where the optimism is emanating from in the Production Function (PF) method.

- The first important point to be made here is that the investment to growth link may be somewhat distorted at the moment in Europe because of the well known investment deflator problem in the ICT sector which ensures that investment levels in real terms are possibly being biased downwards.
- Secondly, in addition to the TFP gains from the investment which is taking place, there appears to be an additional autonomous acceleration in technical progress which is linked to quality changes in the type of investment which is occurring. These quality change developments cannot be picked up by variables such as the mean age of the capital stock and consequently need to be proxied by "time breaks" which try to pick up structural "breaks" in the long run trend growth of TFP (in fact while no such terms are necessary at the level of the EU15, some have been used for individual Member States and indeed for the US). As can be seen from Table 7 in Section 2.1, the main boost to growth over recent years is coming more from these TFP developments rather than from the capital stock, with the text below going on to discuss these possible "new economy" influences on trend TFP growth. Clearly, however, one must stress that if Europe wishes to replicate the US experience, sector specific TFP boosts will have to be augmented by policy changes and with a substantial increase in the investment share, with, it should be noted, the US managing to boost its investment share by over 6 ½% points over the 1990's expansion.

Section 3.1 presents an empirical assessment of the role recently played by the "new" economy in Europe and the US in terms of growth. The framework used for this exercise is growth accounting which in this analysis serves the dual purpose of firstly, providing an idea of the magnitude of the direct effects on growth and secondly, it helps to determine the size of the technology shock which is a crucial input for the model analysis which is carried out in section 3.2. Giving that the size of the TFP shock in the US can be more easily cross-checked given the availability of complementary US data sources, the general equilibrium analysis in 3.2 is therefore more important for assessing the size of the technology shock in the EU, especially to ascertain whether a pessimistic, central or optimistic assumption concerning TFP developments in the EU's ICT sector is the most prudent assumption to be made.

²⁹ A much more comprehensive treatment of this issue is included in the Commission services publication "The EU Economy - 2000 Review" and in Roeger (2001).

3.1 : GROWTH ACCOUNTING ANALYSIS : "NEW" ECONOMY EFFECTS ON POTENTIAL GROWTH IN THE SECOND HALF OF THE 1990'S

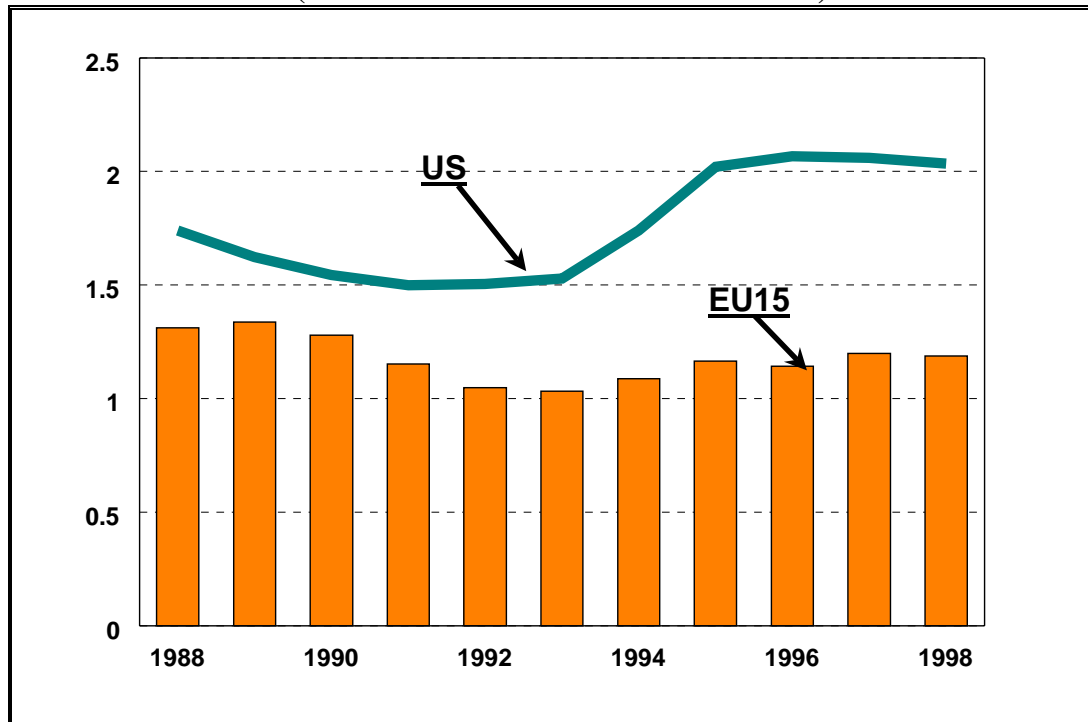
It is now generally accepted that the 1990's boom in the US was to a large extent due to the growth impact of both an expansion in the ICT (Information and Communication Technologies) share of total investment allied to technical progress in the production of ICT goods (see, for example, Jorgensen and Stiroh (2000a) or Oliner and Sichel (2000). Europe is widely regarded as lagging behind the US with respect to both ICT investment and production, although there are also signs of a "new" economy emerging in the EU. This sub-section will firstly survey the empirical evidence concerning the size of ICT production and investment in the EU (compared to the US) and will use this information to assess empirically the growth implications of these developments using the production function framework.

INFORMATION TECHNOLOGY AND GROWTH : WHAT ARE THE TRANSMISSION MECHANISMS : Three channels are usually stressed in discussions on the growth effects of ICT:

- **Firstly**, technical progress is assumed to be occurring in the production of ICT goods, as indicated by a secular trend of steadily falling prices for computer and telecommunications related equipment etc.
- **Secondly**, falling prices for ICT equipment leads in turn to a decline in the capital costs faced by firms and consequently to increases in real investment rates and productive capacity. This capital deepening / accumulation process contributes to higher labour productivity growth even if TFP growth remains constant.
- **Finally**, there may be other positive growth spillovers from ICT investment, including both embodiment effects associated with a more modern capital stock and possible tangential gains in areas such as network externalities. While this third growth promoting channel may exist, it should be emphasised that the empirical supporting evidence for its existence is still lacking, even in the US.

CHANNEL 1 : THE GROWTH CONTRIBUTION OF ICT PRODUCTION (I.E. THE TFP CHANNEL) : Technical progress occurring in the production of ICT equipment has an immediate effect on the overall rate of potential output growth since it increases aggregate TFP. It has been shown by Domar (1961) that aggregate TFP can be represented as a weighted average of sectoral TFP, with the weights being calculated with reference to the production share of individual sectors in total GDP. It is well known from the US literature that technical progress has accelerated in the second half of the 1990's in the production of a large range of ICT related equipment and in particular computers and semiconductors. According to the figures provided by Oliner and Sichel, the **annual** rate of TFP growth in the computer and semiconductor sectors increased by over 5 and 20 percentage points respectively between the first and the second half of the 1990's. The weighted average acceleration for the ICT sector as a whole comes out at around 11%.

GRAPH 17 : ICT PRODUCTION*
(ICT OUTPUT AS % OF TOTAL OUTPUT)



** Data for the ICT sector are all in nominal terms - consequently, given the substantial price declines which have occurred in this sector, over the time period being reviewed in this graph, the picture in real terms would undoubtedly show a much greater upward trend.*

Turning to the Community situation, and taking into account the sectoral output share of ICT firms in EU countries and the evolution of this share in the 1990's, a slight increase in aggregate TFP growth is to be expected even if one assumes that the TFP acceleration in the ICT producing sector has been smaller in Europe than in the US. Applying these ICT productivity growth rates to the corresponding ICT related sectors in the EU's Member States (and for comparison to the equivalent sectors in the US) yields the contributions to, economy-wide, TFP growth of the ICT production sector. As can be clearly seen in Table 11, when this exercise is carried out for the US, it is encouraging to find that it produces a similar TFP growth contribution as obtained by Oliner and Sichel. According to the Oliner and Sichel calculations, intertemporal TFP growth differentials are generated by increasing the share of ICT equipment production in the overall output of an economy. Consequently, if one uses this as the determining factor, then countries such as Finland, Sweden and Ireland, in particular, but also the Netherlands and the UK, would benefit disproportionately compared with the remaining Member States since the ICT sector accounts for a greater proportion of overall output in these countries. As Table 11 shows, over the period 1995-98 compared with 1990-95, four of these five Member States have experienced roughly a doubling of the contribution of the ICT producing sector to aggregate technical progress, with the remaining countries (excluding Portugal) only managing an increase of around 50%. It should be stressed here that TFP growth can be interpreted as potential output growth and consequently translates one for one into higher rates of sustainable GDP growth.

TABLE 11 : ICT PRODUCTION EFFECTS
CONTRIBUTION TO TFP GROWTH OVER THE 1990's (% POINTS)

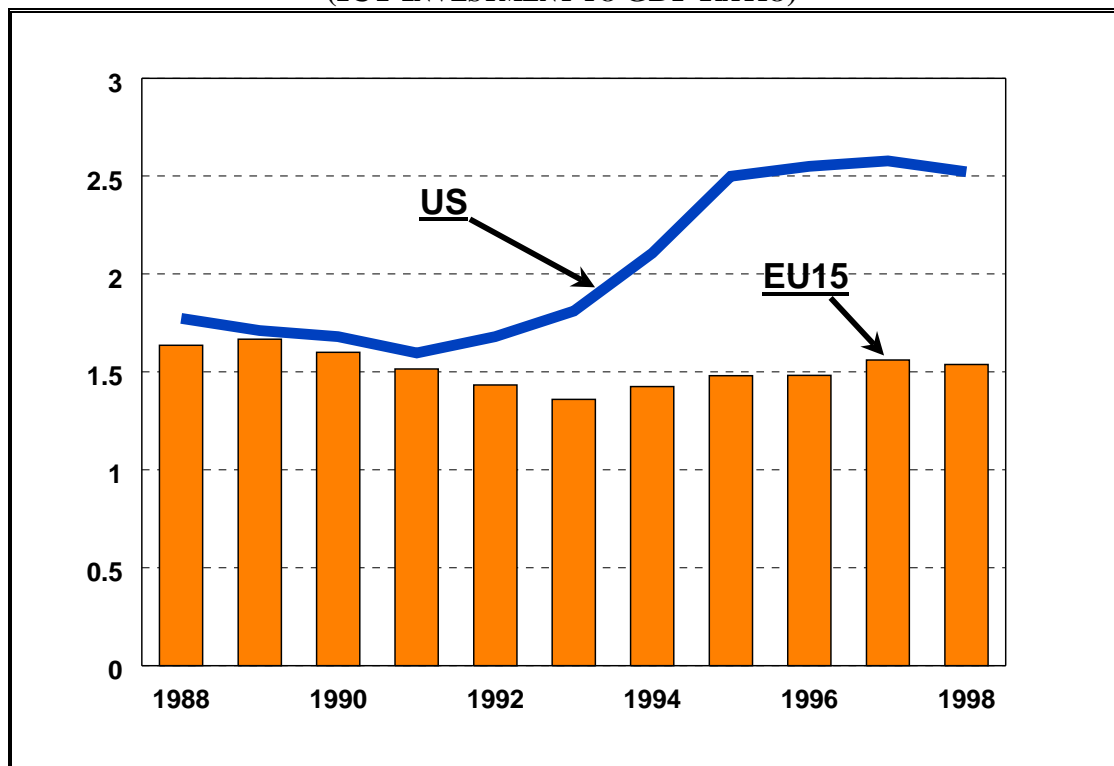
	TFP GROWTH INCREASE IN THE EU'S ICT SECTOR IDENTICAL TO THAT IN THE US		TWO SCENARIOS FOR 1995-1998	
			No TFP Growth Increase in the EU's ICT Sector	TFP Growth Increase in EU ICT Sector = 50% of that in the US
	1990-1995	1995-1998		
Belgium	0.16	0.22	0.14	0.18
Denmark	0.04	0.06	0.04	0.05
Germany	0.13	0.19	0.12	0.16
Greece	0.02	0.04	0.03	0.03
Spain	0.09	0.14	0.09	0.12
France	0.14	0.25	0.15	0.20
Ireland	1.09	2.17	1.41	1.79
Italy	0.13	0.19	0.12	0.15
Netherlands	0.18	0.27	0.18	0.22
Austria	0.10	0.18	0.11	0.14
Portugal	0.11	0.22	0.13	0.17
Finland	0.16	0.38	0.25	0.31
Sweden	0.15	0.27	0.17	0.22
UK	0.17	0.33	0.21	0.27
EU15	0.14	0.24	0.15	0.19
US	0.23	0.50		

CHANNEL 2 : THE GROWTH CONTRIBUTION OF ICT-INVESTMENT (I.E. THE CAPITAL ACCUMULATION CHANNEL) : Deciphering the growth impact of the ICT sector in terms of investment is unfortunately difficult here in Europe since statistical offices in the EU do not provide a breakdown of capital and investment for detailed products and services. Consequently, the individual capital stock series for the relevant ICT products are not available for EU countries. As discussed earlier, an additional complication concerns the measurement of prices for ICT goods. A lot of work has been done in the US on constructing appropriate deflators in the presence of quality change, with the methods developed in this research effort now being used in the construction of deflators for some goods with rapid technological change. In Europe only a few countries have so far experimented with these methods (for example France and Sweden). It is well known that traditional deflators tend to underestimate the degree of price decline for ICT goods. This makes it difficult to compare real ICT investment between the US and the EU³⁰. Consequently, because

³⁰ This significantly biases the rate of productivity growth in the EU. Switching to hedonic deflators for computer hardware and related high tech components would have increased EU GDP growth by 0.25% points per annum over the last 5 years (see S. Cecchetti 2000). This view is backed up by the results from a EUROSTAT taskforce in 1999 which found a large dispersion in computer price declines as reported by statistical offices in the 1990's (from 10% to nearly 50%) and calculated that this range could affect GDP growth rates by about 0.2-0.3 of a % point per year.

of these latter statistical inadequacies here in Europe, any growth accounting exercise for the EU countries has to be based on various assumptions concerning the evolution of both the ICT capital stock series and of investment goods prices. Table 12 gives estimates from a growth accounting exercise using two alternative assumptions regarding ICT deflators.

GRAPH 18: ICT INVESTMENT*
(ICT INVESTMENT TO GDP RATIO)



** Data for the ICT sector are all in nominal terms - consequently, given the substantial price declines which have occurred in this sector, over the time period being reviewed in this graph, the picture in real terms would undoubtedly show a much greater upward trend.*

As indicated in table 12, the ICT investment contribution to growth has been rising in the EU as well as in the US, although most EU countries still lag behind the American performance. However, as against this, some EU countries with large ICT investment shares also show growth contributions similar to the US. In this regard, Ireland is a particularly interesting case, with the growth contribution of the ICT sector for the Irish economy by far exceeding even that for the US. In fact, ICT investment (as a share of GDP) has increased in virtually all of the EU countries. Though it is premature at this stage to clearly distinguish between a purely cyclical upturn in the investment to GDP ratio and a more secular increase, developments over the last 5 years nevertheless suggest that the EU's output capacity may have risen. Not only has productive capacity increased, but embodiment effects coming from the increase in total investment may have additionally accelerated the rate of TFP growth. A lack of a sufficiently long time series on ICT production shares precludes a full statistical analysis of the TFP effects of ICT production at this particular moment in time.

**TABLE 12 : ICT INVESTMENT EFFECTS
CONTRIBUTION TO POTENTIAL GROWTH IN THE 1990's (% POINTS)**

	ICT PRICE DECLINE IN THE EU IDENTICAL TO THAT IN THE US		ICT PRICE DECLINE IN THE EU = 50% OF THAT OF THE US	
	1992-1994	1995-1999	1992-1994	1995-1999
Belgium	0.35	0.60	0.35	0.51
Denmark	0.22	0.38	0.22	0.32
Germany	0.25	0.41	0.25	0.35
Greece	0.12	0.21	0.12	0.18
Spain	0.19	0.39	0.19	0.33
France	0.24	0.42	0.24	0.35
Ireland	0.84	1.91	0.84	1.64
Italy	0.25	0.42	0.25	0.36
Netherlands	0.41	0.67	0.41	0.56
Austria	0.24	0.41	0.24	0.34
Portugal	0.25	0.55	0.25	0.47
Finland	0.31	0.63	0.31	0.53
Sweden	0.30	0.68	0.30	0.57
UK	0.35	0.64	0.35	0.54
EU15	0.27	0.49	0.27	0.41
US	0.40	0.87	0.40	0.87

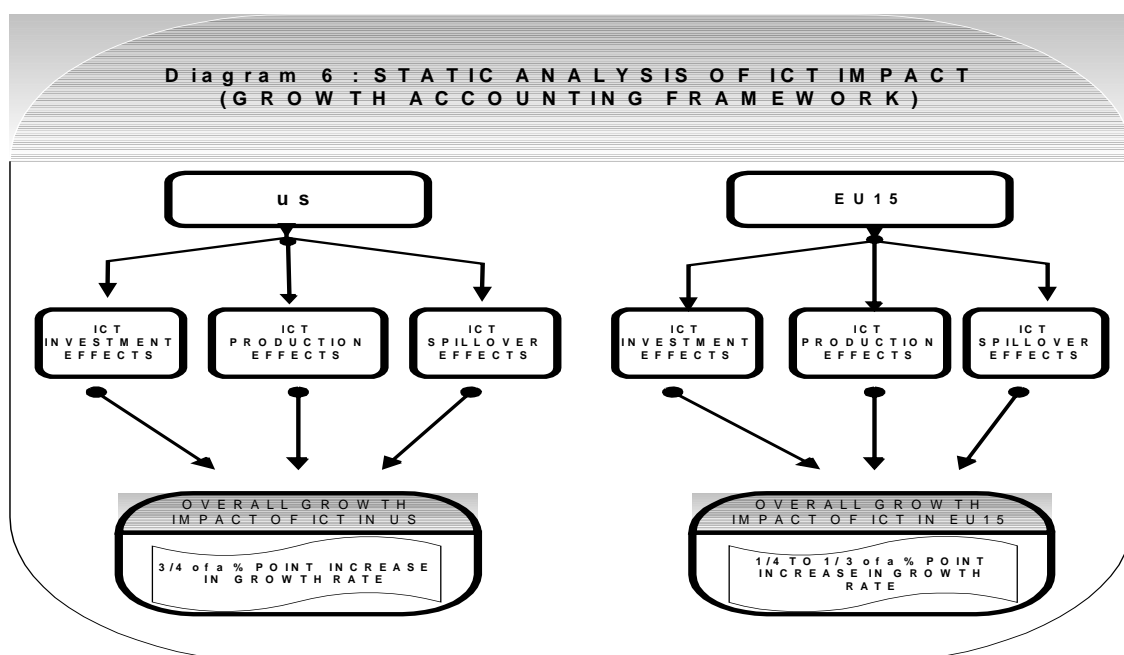
CHANNEL 3 : SPILLOVER EFFECTS FROM USING ICT : Many commentators suggest that there might be additional economic gains from the ICT revolution in the form of embodiment effects or positive spillover effects (network externalities). In this case one should also observe TFP gains in those sectors using ICT capital more intensively or, if the externalities/spillover effects would be economy-wide it could also imply a general increase in the rate of TFP growth. If the available studies in this area are to be believed, the contribution to potential growth from this third channel is likely to be small. At least at the macroeconomic level there is so far little evidence of significant spillover effects, with even the results for the US not suggesting that TFP has increased strongly in ICT using sectors.

However, before reaching premature conclusions on this point, it must be noted as Griliches (1994) observed that more than 70% of private sector US computer investment is concentrated in the service industries i.e. in sectors where output is not well measured or even the concept of output is not well defined. Though measurement constitutes a possible explanation it is hard to tell how serious the problem is. There are various counter-arguments as, for example, put forward by Gordon (1999, 2000) and Triplett (1999). Both Gordon and Triplett argue that though it may appear that the number of new companies and new products associated with ICT is impressive, it may not be as significant when compared to former technological revolutions because of a *base effect*. In other words, because the number of products and services is so much larger now than it was with former

technological revolutions, it requires many more innovations per year in order to achieve the same growth rate in productivity. Therefore, simply looking at the absolute number of new products and services could be quite misleading. Triplett makes an additional point: since most of the computer-using service industries provide intermediate-level inputs to other industries they do not show up in the aggregate statistics. So even if there is a measurement problem, only that fraction of services that enters directly into private consumption constitutes a problem. Business services, for example, do not constitute a difficulty for the measurement of aggregate productivity because any error is netted out in the aggregation process.

WHAT DOES THE GROWTH ACCOUNTING ANALYSIS IMPLY FOR POTENTIAL GROWTH IN THE EU IN THE SECOND HALF OF THE 1990'S:

Given that the above analysis implicitly assumes that any impact on growth from the third growth promoting channel is likely to be small, assessing the effect on potential growth essentially involves an evaluation of the direct impact on growth of producing ICT products plus the growth enhancing effects of boosting the relative share of ICT investment goods in the overall capital stock. It is important to stress that these latter two effects are not additive since the results presented in Table 12 for the contribution to potential growth through the ICT investment channel are gross effects. The net addition to growth from increased investment in ICT goods would be smaller since substitution effects are at work, with other areas of investment spending being cut back to fund the additional ICT purchases. However, while the total effect on potential growth is therefore difficult to decipher, it is possible to roughly say that the contribution of the ICT sector to EU potential growth over the second half of the 1990's has been between 20-40% of the boost to growth achieved in the US. On the assumption that a 3/4 of a % point increase in US potential growth is reasonable given the foregoing analysis, this would translate into an increase of between a 1/4 and a 1/3 of a % point in terms of the EU's potential growth rate over this period, which on its own could represent all of the production function estimated increase in potential output between the first and second halves of the 1990's.



3.2 : DYNAMIC GENERAL EQUILIBRIUM ANALYSIS

-ASSESES THE SHORT, MEDIUM AND LONG RUN EFFECTS OF AN ICT TECHNOLOGY SHOCK-

The dynamic analysis included in this section tries to decompose the widening growth differential between Europe and the US in the 1990's into contributions coming from cross country differences in the size of the technology shock itself and contributions coming from institutional differences in the area of capital adjustment costs and labour market rigidities. Obviously such a “decomposition” must go beyond a pure growth accounting analysis and requires a more structural form of analysis where investment behaviour and labour markets must explicitly be specified. A more structural approach is also required because strong trade and financial linkages between Europe and the US are likely to lead to substantial international spillover effects from technological advances in either of the two geographical areas. This decomposition analysis of the growth differential into technological factors, international spillovers and institutional rigidities is carried out using a “two-country-two-sector-two-skills” variant of the conventional neoclassical growth model, calibrated for the EU and the US³¹.

WHY DO WE NEED A GENERAL EQUILIBRIUM ANALYSIS ? :There are a number of advantages to using such a model based approach, including :

- **Firstly**, the macroeconomic effects of a technology shock, such as that represented by rapid efficiency gains in the production of ICT goods can be very different from the initial impulse, depending on how other factors of production adjust to the shock. These dynamic effects could be regarded as a type of "fourth channel" through which the ICT sector affects the growth outlook and consequently a model framework for checking the extent of these effects would appear to be necessary. In this regard, the model can be used to check the results from the static analysis to see, when one takes into account the, above mentioned, normal dynamic interactions and feedback effects in an economy, whether the growth rate estimate from the static analysis should be reduced or increased. For example, to the extent to which ICT capital accumulation acts as a replacement for other factor inputs and the restructuring leads to frictions in capital and labour markets, this fourth channel could potentially have some negative effects on growth, at least in the short and medium run. Consequently, the macroeconomic effects of ICT on growth could be smaller than predicted by a pure growth accounting exercise.
- **Secondly**, model simulations are particularly important for assessing the robustness of the TFP assumptions to be used for the ICT sector in Europe. While the US figures can be relatively easily cross-checked using published data sources, the situation in Europe is very different. By simulating the model with various TFP assumptions for the ICT sector, one can assess which assumption is the most credible when the consistency of the results are compared with the actual outcomes for a range of indicators including ICT investment, production and import share developments³².

³¹ All the technical details concerning this two-country model are contained in Roeger (2001).

³² In terms of import share developments, in 1993 the EU15 as a whole imported over 18% of its ICT equipment needs from the US compared with a share of a little over 6% of US ICT sales being imported from EU countries. Furthermore, the relative

- **Thirdly**, given the level of trade and financial integration between the US and the EU, the model can be used to assess the importance of international spillover effects in determining the growth effects from the ICT shock.
- **Finally**, simulations can be useful in isolating the relative importance of the various arguments which have been put forward by commentators to explain the "root" causes of the widening growth differential between the US and Europe over the last number of years. For example, how credible is the view which stresses that differences in the way markets function could significantly affect how technological impulses from the ICT sector get transmitted throughout the economy, not only in terms of the magnitude of these effects but also in terms of their sign.

TECHNOLOGY SHOCK SIMULATIONS FOR THE US AND EU15

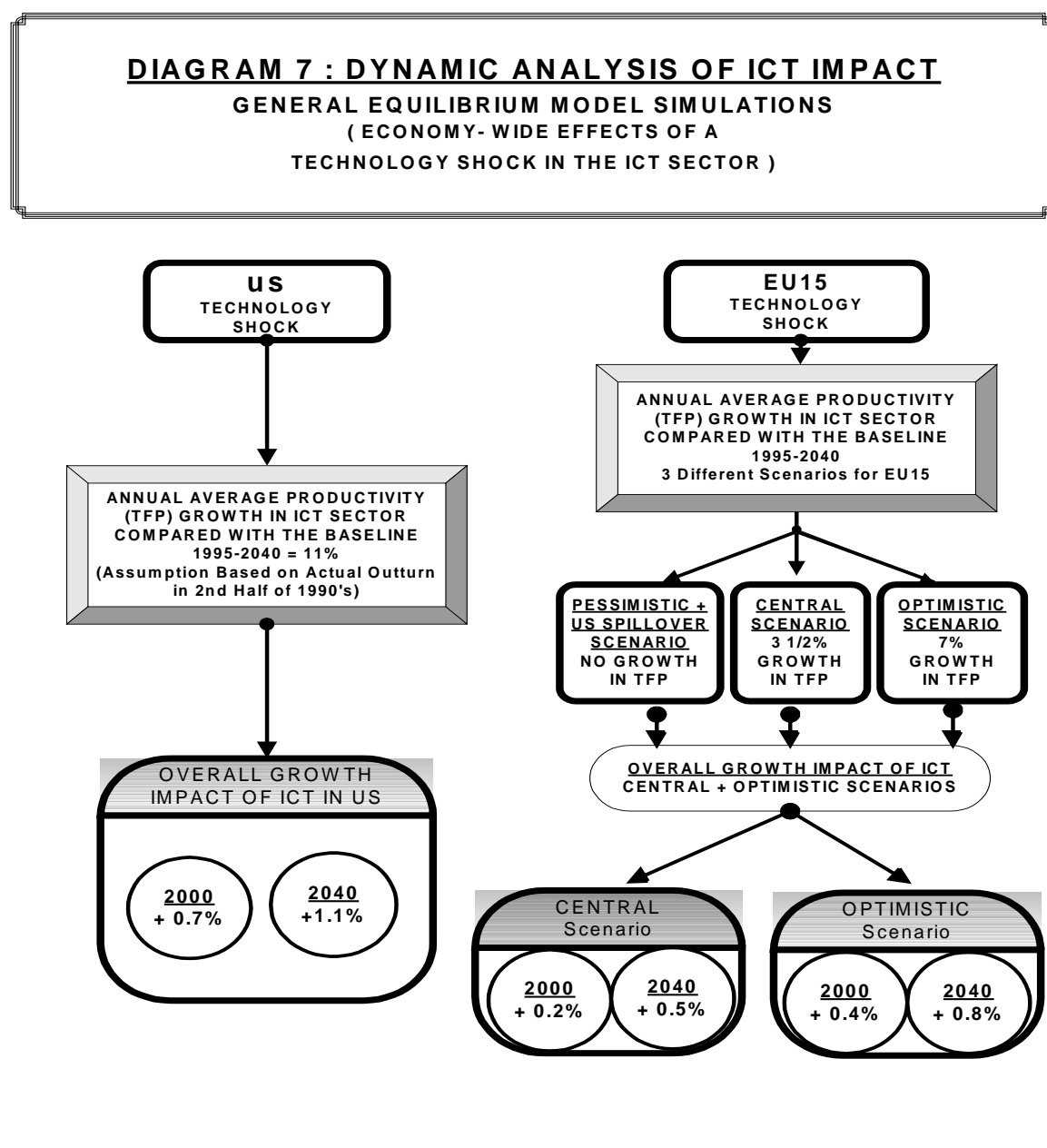
In order to carry out a dynamic macroeconomic analysis of the ICT impact on growth in the US and Europe, as mentioned earlier, a "two-country-two-sector-two-skills" dynamic general equilibrium model is set up which allows for differences between the EU and the US in terms of both labour market imperfections and investment adjustment costs. Consistency with the growth accounting analysis is preserved by using a conventional neoclassical growth model with constant returns to scale technology, which is disaggregated on the production side into an ICT and a non-ICT sector. For the purposes of this analysis it will be assumed that the higher growth rate of technical progress in ICT production which has been observed since the mid 1990's will persist over a period of 50 years. Aggregating the subsector information, the growth rate of TFP in the ICT sector as a whole has increased by 11% points in the US since the mid-1990's³³ and this rate of acceleration is assumed to persist over the long run. While this latter technology assumption may appear optimistic, especially given the productivity gains already achieved in the ICT sector, the size of the technology shock should really be interpreted as a proxy for continued rapid technological progress in the economy as a whole, be it from ICT or other "new" economy sectors which are still in their infancy or, perhaps, have still even to emerge.

Assuming identical growth rates of TFP in the ICT sub-sectors in the EU, but taking into account the different sectoral composition, namely a smaller share of semiconductor production where most of the TFP acceleration took place in the 1990's, one arrives at a TFP acceleration of 7% for the EU. Given the evidence provided in section 3.1, it is doubtful whether productivity growth has actually accelerated at the same speed as in the US, and consequently the model is used to simulate the effects of three different TFP assumptions for Europe's ICT sector. In the first scenario an identical productivity acceleration is assumed while in the second scenario an acceleration of only 50% compared to the US is considered. The third simulation assumes that there was no acceleration of ICT TFP growth in Europe,

EU15 position deteriorated over the 1990's with ICT imports from the US rising to 23% for the EU15 while equivalent US imports from the EU actually fell slightly over the same period.

³³ TFP growth in the ICT sector as a whole has accelerated from an annual average rate of increase of around 15% over the period 1990-95 to a rate of 26% over the period 1995-98. For the purposes of the technology simulations undertaken in the rest of this section, this 11% points acceleration in the growth rate of ICT TFP over this period constitutes the size of the technology shock for the US given to the model, with the ICT TFP growth rates for the period 1990-95 being used as the baseline scenario.

which acts both as a pessimistic scenario and as an illustration of the size of any international spillover effects on Europe from technical advances in the US.



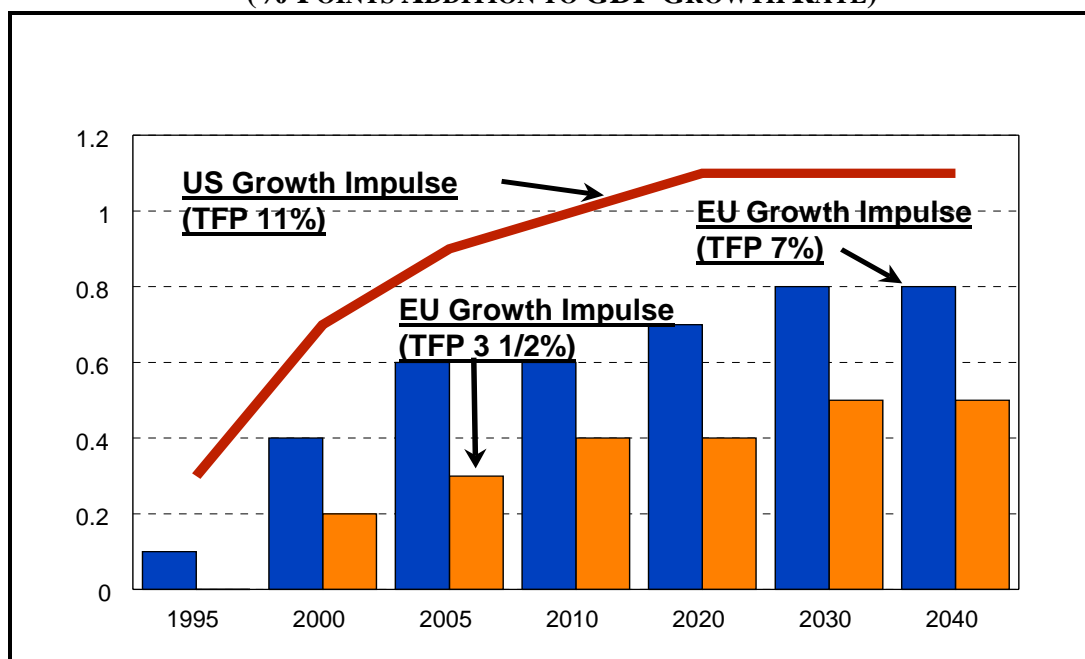
GROWTH RATE EFFECTS OF THE VARIOUS TECHNOLOGY SHOCKS :

- CENTRAL SCENARIO FOR THE US :** A permanent shock to the ICT TFP growth rate of 11% leads to a permanent increase in the growth rate of GDP in the US, with the growth rate being 0.7% points higher after 5 years (i.e. in 2000) and about 1% point higher after 15 years. Of course, if the acceleration in the TFP growth rate in the ICT sector cannot be maintained, with growth rates for example returning to the baseline rates achieved in the early 1990's, then following a transition period (during which the growth rate would continue to be supported by

ongoing, but declining, rates of ICT capital accumulation) the US GDP growth rate would eventually fall back to the growth rates experienced in the first half of the last decade.

- **OPTIMISTIC SCENARIO FOR THE EU : LARGE TFP SHOCK :** Under the optimistic assumption on European ICT TFP growth (i.e. 7%), the model predicts an increase in the growth rate of GDP of 0.4% after the first five years (i.e. in 2000) and a further acceleration to 0.8% after 40 years of uninterrupted TFP gains in the ICT producing sector (i.e. with annual growth rates in TFP being 7% points higher than the rates achieved in the baseline period of 1990-95). In line with the evidence presented earlier, on the magnitude of the technology shock in the European ICT sector, the results of this model simulation suggest that such a scenario would be too optimistic for the EU.
- **CENTRAL SCENARIO FOR THE EU : SMALL TFP SHOCK :** With a more modest assumption on the ICT technology acceleration in Europe (i.e. 3 ½% annual TFP growth), the model replicates surprisingly well the observed change in the ICT production, investment and import share in the EU. This can be regarded as important evidence in favour of lower rates of technical progress in recent years. A technology shock of this order of magnitude would only lead to a slow acceleration of GDP growth in Europe which according to these results would be 0.2% points higher after 5 years. However, this process will continue and the growth rate could go up by 0.5% in the long run.
- **CENTRAL SCENARIO : IMPACT OF US SPILLOVER EFFECTS ON EU GROWTH :** In the above "central" EU simulation, the growth effects appear disproportionate given the small size of the technology shock, with the long run growth rate in the EU growing by 1/2 a % point compared with an acceleration of 1% point in the US, despite a rate of technical progress in the EU's ICT producing sector which is only about 30% of that in the US. A plausible explanation for this phenomenon are international spillover effects. In order to isolate these effects, a type of "anti-monde" simulation was run where technical progress is concentrated entirely in the US. This purely illustrative simulation would represent a "worst case" scenario, involving continuous technical progress in the US combined with a technologically stagnant high tech sector in the EU. While initially negative for growth in the EU, this scenario would still result in a small boost to EU growth after 15-20 years of 0.1 of a % point, rising to 0.2 after 35-40 years. These positive spillover effects emerge since in the long run the corporate sector as a whole in Europe would benefit from the efficiency gains in the US ICT sector, with the latter being transmitted to Europe in the form of lower investment goods prices which the greater efficiencies would inevitably generate. Consequently, of the 0.5 % point boost to the EU's growth rate at the end of the simulation period, for the "central" TFP scenario, 40% of it could be due to positive spillover effects from US technological advances.

GRAPH 19 : GROWTH IMPULSE FROM TFP INCREASES IN ICT SECTOR -US V EU15
(% POINTS ADDITION TO GDP GROWTH RATE)



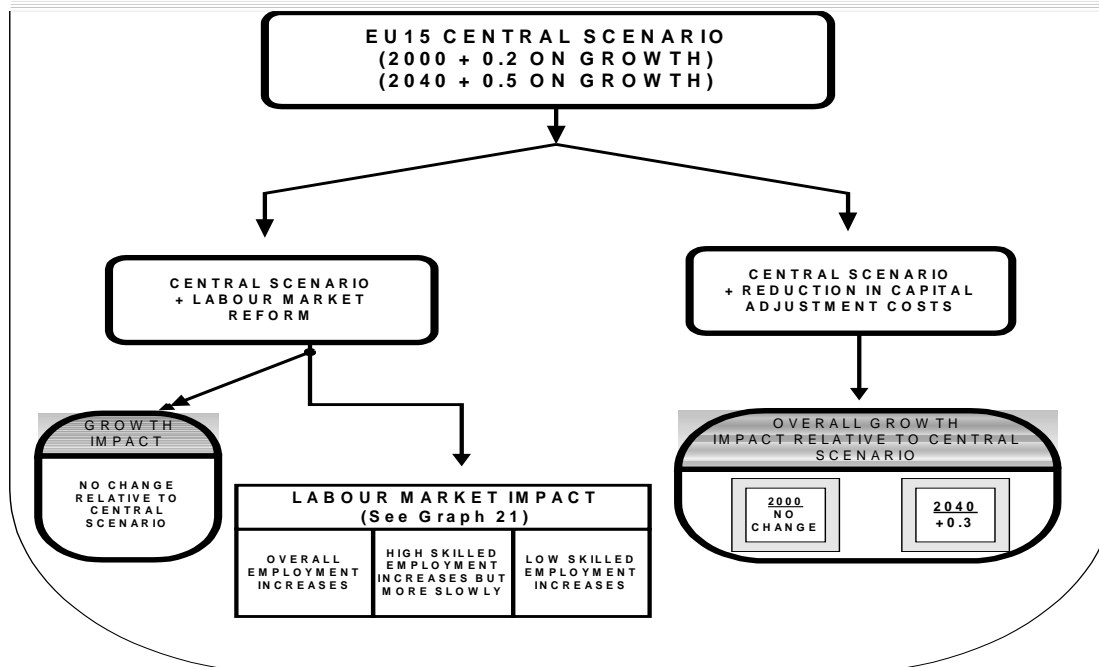
STRUCTURAL DIFFERENCES BETWEEN EUROPE AND THE US
(HOW IMPORTANT ARE CAPITAL ADJUSTMENT AND LABOUR MARKET RIGIDITIES
IN EXPLAINING THE RISING GROWTH DIFFERENTIALS BETWEEN BOTH AREAS?)

Some recent research indicates that, at least initially, institutional differences between the US and EU economies, which directly impact on the functioning of markets, could have a strong impact on how the ICT technology shock was transmitted in both areas. There is a widespread belief in fact that both capital and labour markets are more flexible in the US than in the EU and it is therefore often argued that market rigidities in Europe are a crucial factor for explaining the growth differential between the US and the EU in the 1990's. In order to analyse and quantify the role of market rigidities, the model allows for capital adjustment costs³⁴ and labour market imperfections³⁵. This section will therefore attempt to answer the important policy question of whether Europe could have benefited substantially more from the ICT revolution if it had a more flexible economy in the form of lower capital adjustment costs and less relative wage rigidities.

³⁴ Capital adjustment costs can take various forms, such as, for example, government regulations and organisational adjustment and learning frictions within firms. Investment rigidities can also arise in the form of information, transaction and monitoring costs of financial intermediaries (venture capital markets, equity financing). Differences in financial markets, in fact, are often emphasised as being especially crucial in any EU-US comparison.

³⁵ A conclusion common to many studies on the European labour market is that there is a need for increased flexibility, especially when compared to the US labour market. There are at least two dimensions in which EU labour markets differ from those in the US. Firstly, there are differences in hiring and firing costs, due to differences in regulations regarding advance notice and severance pay, although economists generally agree that these differences would not appear to be responsible for a lack of ICT investment activity in Europe. Secondly, there is relatively little wage flexibility across skill groups in EU countries compared to the US and it is the growth implications of the latter which is focussed on in the labour market simulation in this section.

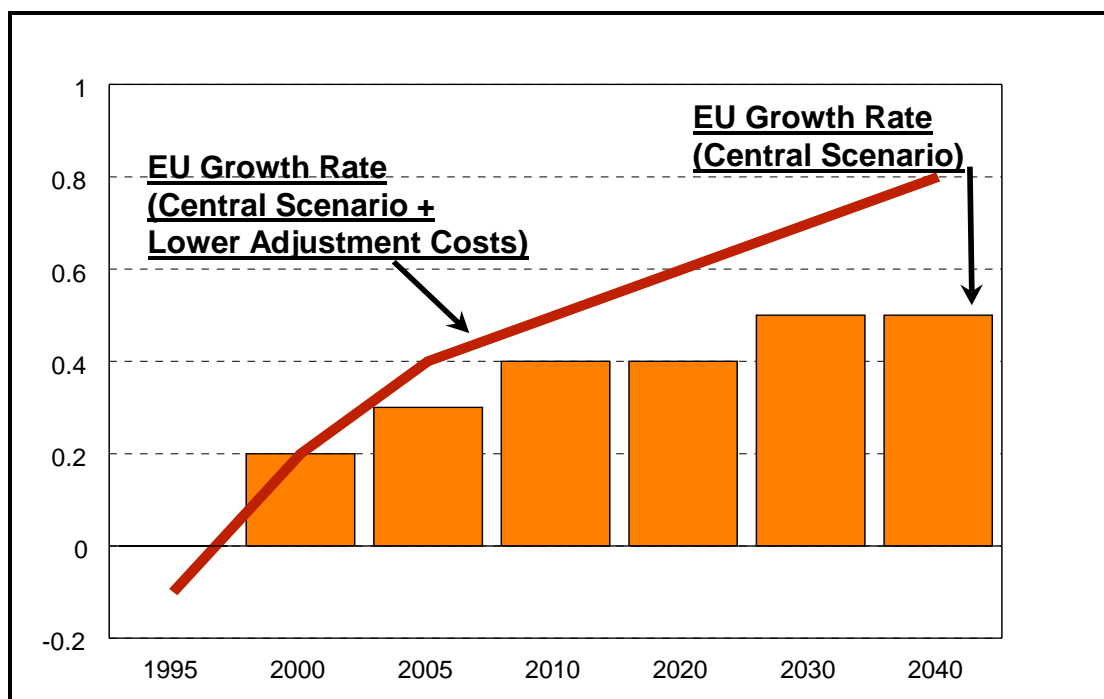
DIAGRAM 8 : EU TECHNOLOGY SHOCK - CENTRAL SCENARIO (IMPACT OF INSTITUTIONAL RIGIDITIES)



CAPITAL ADJUSTMENT COSTS SCENARIO³⁶ : Assuming TFP increases in the ICT sector which are identical to the central scenario described above, how would the EU economy respond to such a technology shock if capital adjustment costs were actually reduced to US levels. As can be seen from graph 20, reducing adjustment costs for capital could lead to substantial long term gains, with the increase in the long run growth rate induced by the TFP shock being up to 0.3% points higher than it would otherwise have been. However, in the short run, growth differentials would actually be small and hardly visible in the first 5 years. Consequently, at least within the technological constraints inherent in standard growth models, higher adjustment costs in Europe cannot explain the, ICT induced, US-EU potential growth differential in 2000, without allowing for substantially higher rates of technical progress.

³⁶ Capital Adjustment Costs : The question arises as to how to quantify these adjustment costs in a simple macroeconomic indicator in order to compare their magnitude across countries. From recent business cycle research it is well known that there is a strong link between the magnitude of adjustment costs and the volatility of investment over the cycle i.e. in an economy without adjustment costs, aggregate investment would adjust instantaneously to demand and productivity shocks and one should therefore observe a high volatility of investment. In contrast, if firms face strong costs of adjustment, then investment should be a smoother process. The observed investment volatility in the US and Europe is consistent with the view that adjustment costs for capital are smaller in the US. The respective investment volatility can be matched by the model if one allows adjustment costs to be 13% of total investment expenditure in Europe and 7% in the US. For computer capital, adjustment costs amount to 22% of total investment expenditure in the US and to 40% in the EU. Allowing for larger adjustment costs related to ICT investment is consistent with the results of a lot of research in this area.

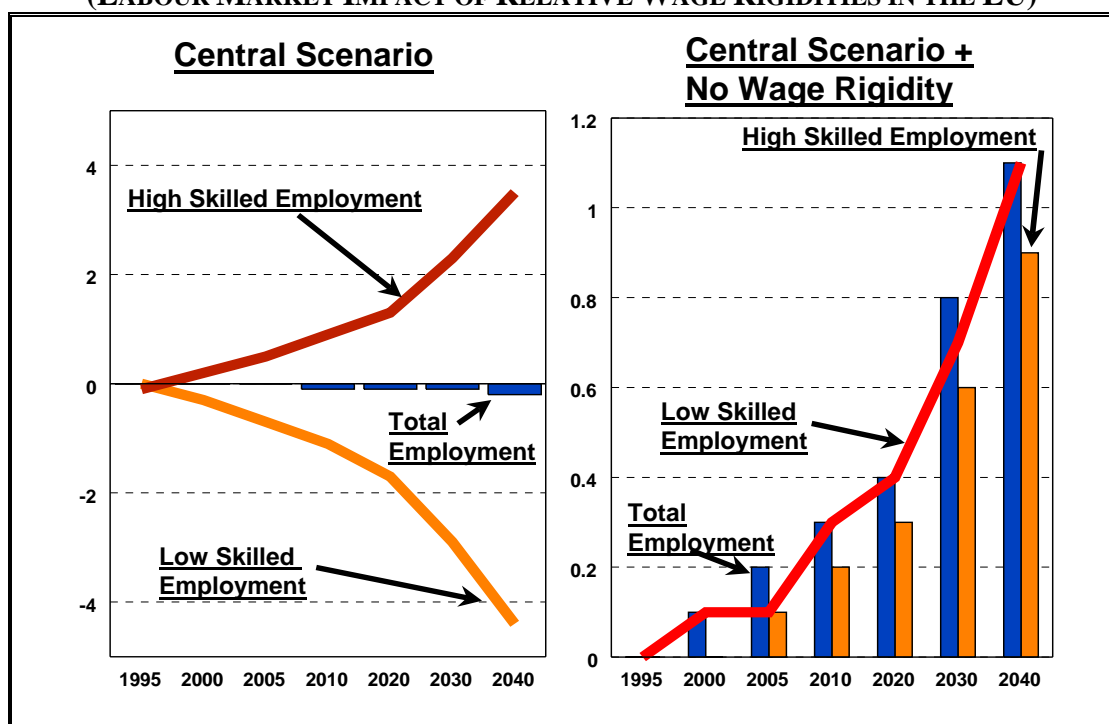
GRAPH 20 : CENTRAL EU SCENARIO
(ADDITION TO GROWTH RATE OF LOWER CAPITAL ADJUSTMENT COSTS)



MORE WAGE FLEXIBILITY IN EUROPE SCENARIO³⁷ : As graph 21 shows, the most striking implication of more wage flexibility in Europe would be an increase in low skilled employment, however at the cost of rising wage dispersion. On the other hand, increasing wage flexibility in Europe would not lead to a substantial increase in the growth rate of GDP. It is interesting to note that the increase in the investment to GDP ratio would actually be smaller, thus labour market reforms would actually slow down the productivity increase and would make growth more labour intensive. This result is not inconsistent with the historically high growth rate of capital intensity in Europe, compared to the US. Therefore, somewhat paradoxically, labour market rigidities actually encourage firms to invest in new, labour-saving, technologies which boost productivity but substitute for low-skilled workers.

³⁷ It has been widely documented that in contrast to the EU where one observes rising low skilled unemployment, one observes rising skill premia in the US. These trends could be a direct consequence of differences in the degree of relative wage rigidity between Europe and the US when technical progress is skill biased in favour of high skilled workers. It could therefore be particularly relevant in the ICT context since there exists empirical evidence which suggests that low and high skilled workers are affected differently by ICT investment because of different degrees of substitutability for both types of labour with capital. The current technological revolution, which is associated with a rapid fall of investment goods prices poses a special risk for low skilled workers, because the bulk of empirical evidence points in the direction of high substitutability of low skilled workers with capital. The functioning of labour markets may therefore be crucial for the transmission of the technology shock. A flexible labour market could substantially speed up the reallocation of labour to other uses, while labour market rigidities could mitigate the growth effects from ICT.

GRAPH 21 : CENTRAL EU SCENARIO
(LABOUR MARKET IMPACT OF RELATIVE WAGE RIGIDITIES IN THE EU)



3.3 : OVERALL ASSESSMENT OF THE "NEW ECONOMY"

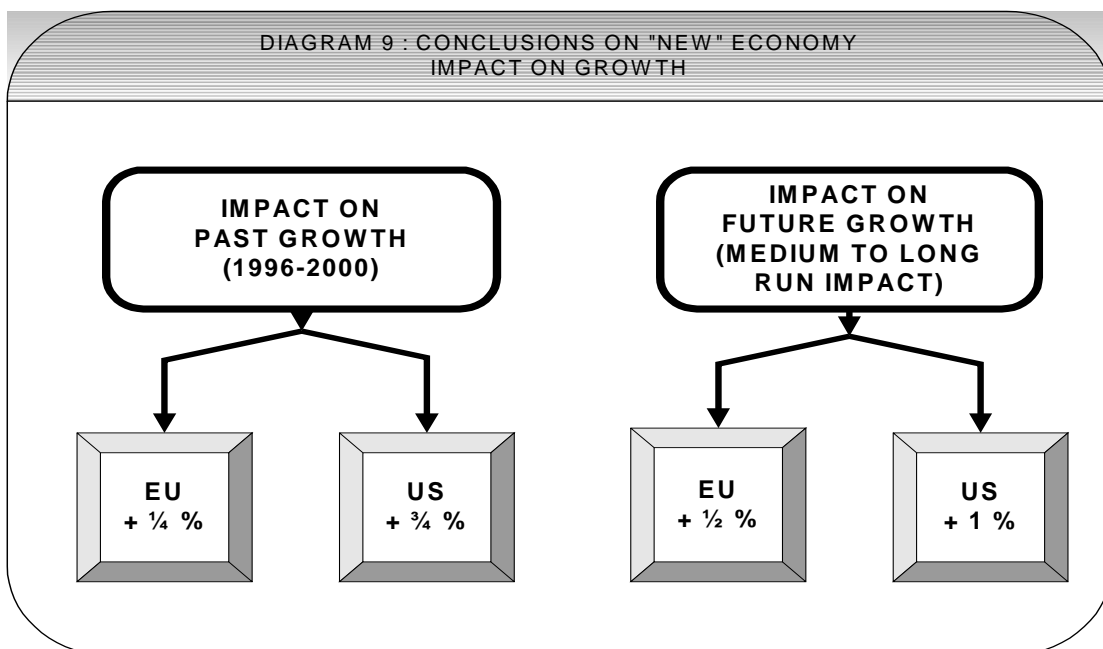
From the static and dynamic analysis of the contribution of the ICT sector to the US and EU economies, it would appear that the EU's potential growth rate has been boosted by about a 1/4 of a percentage point over the second half of the 1990's³⁸, compared with an acceleration of 3/4 of a % point in the US. Under more optimistic assumptions for the technology boost in the EU, the growth rate effect could come close to 1/2 a percentage point. However, the results of the various EU TFP simulations, undertaken to cross-check the results emanating from the growth accounting analysis, suggest that the lower estimate is more compatible with the evolution of ICT investment, production and import shares in Europe over that period. Consequently, it would appear that due to the uneven international distribution of the technology shock, growth accelerates faster in the US because the TFP shock increases productivity directly and therefore shows up earlier in GDP compared with an indirect acceleration in TFP which has been mainly fueled via capital formation in Europe.

This latter conclusion is reinforced by the results from simulations which explore the widely held view that structural impediments to growth, namely high capital adjustment costs and relative wage rigidity, may have prevented the EU from enjoying similar growth rates than the US. By allowing for such structural differences in capital and labour markets the model has the capacity to isolate the importance of

³⁸ It is important to stress that this area wide increase should not be applied equally to all the constituent Member States. As the analysis in Section 3.1 made clear the evidence so far for "new economy" influences on potential growth is restricted to some of the smaller Member States and perhaps the UK.

technological as opposed to structural factors for explaining the growth gap between both areas. From the simulations undertaken, it would appear that, although both capital adjustment costs and wage rigidities lead to welfare losses in Europe, in terms of growth and employment, they cannot explain the growth differential over the last five years. The best explanation would therefore appear to be differences in the rate of technical progress in ICT production. Consequently, rather than blaming “Eurosclerosis” in general for the reason for Europe lagging behind US rates of growth, European policy makers should perhaps instead focus more narrowly on the determinants of the US' apparent comparative advantage in the production of "leading edge", high technology, goods. The simulations suggest that it is the exceptionally high rates of TFP growth in the production of these goods, rather than the associated capital accumulation effects, which has provided the single greatest contribution to the acceleration in the US's growth performance over the recent past.

In terms of extrapolating forward the future impact on growth from the ICT, and similar "new" economy, sectors over the coming years, it should be underlined that the signs for the EU economy are still somewhat unclear from the growth experience of the last five years. However, despite these latter, well documented, uncertainties, if an optimistic view regarding TFP growth is assumed (i.e. that the acceleration in TFP experienced in the ICT sector in the second half of the 1990's persists over the coming decades), then the long run rate of growth could be boosted by 1% point in the US and about half that in the EU and persist at that higher rate of growth over the coming decades.



SECTION 4
EU15 AND US GROWTH SCENARIOS
FOR THE PERIOD 2001-2010

SECTION 4 : EU15 AND US GROWTH SCENARIOS FOR THE PERIOD 2001-2010

HOW SENSITIVE IS POTENTIAL GROWTH TO VARIOUS LABOUR, CAPITAL AND TECHNICAL PROGRESS ASSUMPTIONS

INTRODUCTORY REMARKS : As explained in Section 2 of the paper, the estimate of potential output growth produced by the production function approach gives the growth rate which is consistent with changes in the employment potential, the capital stock and the level of technology (which partly depends on investment) in a particular economy. Whether developments (be they positive or negative) observed over a recent period will persist or not in the future depends fundamentally on the evolution of those factors which are driving labour potential, capital accumulation and TFP. In the case of labour potential those factors are the population of working age, labour force participation rates and developments in the area of structural unemployment. In the case of capital, rates of growth in fixed capital formation or alternatively trends in relation to the investment to GDP ratio are crucial. In the case of TFP, the key driving forces are the autonomous rate of technical progress and the rate of capital accumulation.

Given this emphasis in the production function methodology on the current, as opposed to the future, evolution of the productive capacity of an economy, the purpose of this section is to check whether the more recent growth estimates for both the EU and the US, produced by this methodology, will persist over the medium to long run. Under this view the potential growth rates for 2000 of 2 ¾% for the EU and 4 - 4½% for the US should not be seen as forecasts of medium-term sustainable rates of growth but more as an indication of the technical output capacity of both economies at this one particular point in time. These recent rates can only be sustained in future years if none of the underlying driving forces change, with any, meaningful, forward looking assessment needing therefore to be based on a careful evaluation of the prospects for those contributory factors mentioned in the previous paragraph, over the time horizon to be analysed. This evaluation is carried out in this section through the use of detailed, assumptions-based, scenarios. The paragraphs below give the broad determining features for each of the three scenarios (i.e. pessimistic, central and optimistic), with a detailed assessment of each of the latter provided in the main body of the section.

- **PESSIMISTIC SCENARIO** : This scenario is underpinned by the view that both the slight upturn in potential growth in the EU witnessed over the period 1996-2000 and the much stronger US performance over the same period were essentially only cyclical in origin and consequently the trend TFP growth rates witnessed in the first half of the decade, and indeed over the 1980's as well, will re-establish themselves in both areas over the coming decade. In addition, the upturn in participation rates witnessed over the second half of the 1990's in both economies would also fall back as the pace of growth slows down. This slowdown in participation rates will be particularly painful for the EU since it will more fully expose the start of the longer term decline in the population of working age and its negative implications in terms of the EU's future labour force potential. Finally, investment rates will not be sustained at the high levels of the late 1990's and rates

of growth of the capital stock will return to their long run trend levels. This scenario can be seen as a negation of the "new" economy, suggesting as it does that the long run patterns established over the 1980-1995 period have not been permanently altered by the developments of the last number of years.

- **CENTRAL SCENARIO** : The central scenario gives the "benefit of the doubt" to "new" economy advocates, with the trends established over the second half of the 1990's being used as the basic framework for the assessment for 2001-2010 for both areas. For the EU, in addition to the assumption that the modest, but accelerating, "new" economy effects evident over the late 1990's will persist over the forecast horizon, ongoing labour market reforms are also assumed. The latter reform efforts should result in sizeable labour potential effects both in the form of downward movements in the NAIRU and an ongoing increase in participation rates. In terms of capital formation, the investment pattern which emerged in the second half of the 1990's is maintained for the EU but because of sustainability concerns the US investment to GDP ratio is assumed to fall back to a rate slightly below the average experienced over the period 1996-2000³⁹ and well below the rate achieved in the year 2000. Finally, it should be underlined that for the EU that while this scenario can be seen as a validation of the view that "new" economy influences are at work, this optimism is not Community wide, with at present evidence for such positive TFP effects only clearly emerging in a small, but admittedly, growing number of EU Member States.
- **OPTIMISTIC SCENARIO** : This final set of simulations can be seen as providing a strong endorsement for the growth impact of the "new" economy in both the US and the EU. For the EU the optimistic variant could also be described as a type of "Lisbon Scenario" with Europe taking the necessary structural measures needed to start on the road to becoming "the most competitive and dynamic knowledge-based economy in the world". In this scenario, the employment rate is increased substantially over the period 2001-2010, through both participation rate and NAIRU improvements, and the EU goes on to make a large proportion of the gains in TFP witnessed in the US over the second half of the 1990's, which could add up to 1/2 a % point to the EU's growth rate at the end of the simulation period in 2010.

HISTORICAL EVALUATION OF THE KEY GROWTH COMPONENTS

Table 13 for the EU15 and Table 14 for the US give a breakdown of the evolution of key labour market, capital formation and productivity variables over the period 1966-2000. This information is important for assessing the prudence of the various assumptions made in the subsequent analysis, with graph 22 summarising the contributions to growth from the various components over the last number of decades, and with graphs 23-25 showing the investment to GDP ratio and a breakdown of TFP growth into its exogenous and endogenous components.

³⁹ The 1996-2000 period average of 21% for the US investment to GDP ratio is itself very high relative to the historical levels of this latter ratio.

Graph 22 : Contributions to Growth 1966-2000

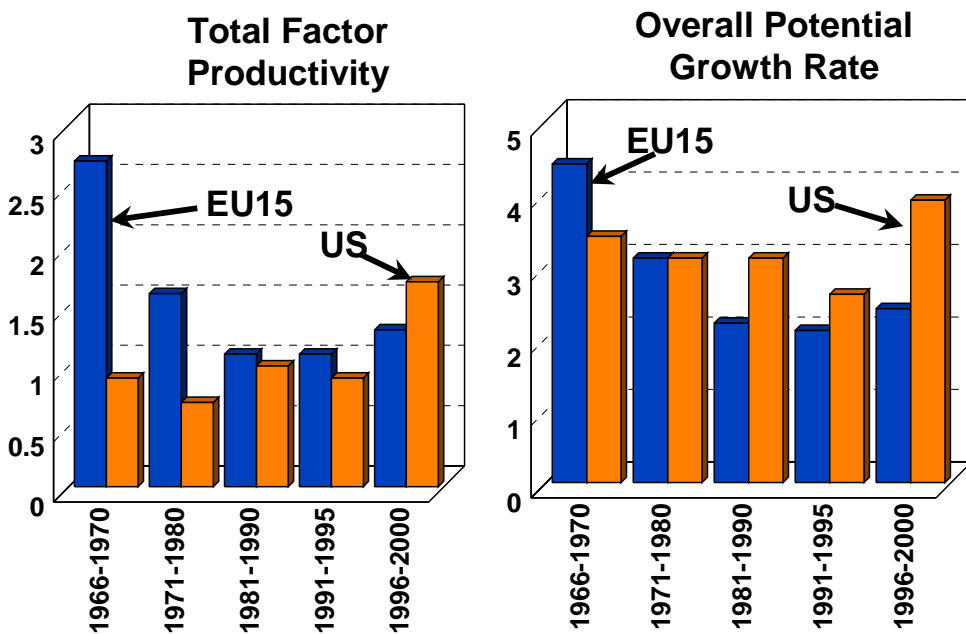
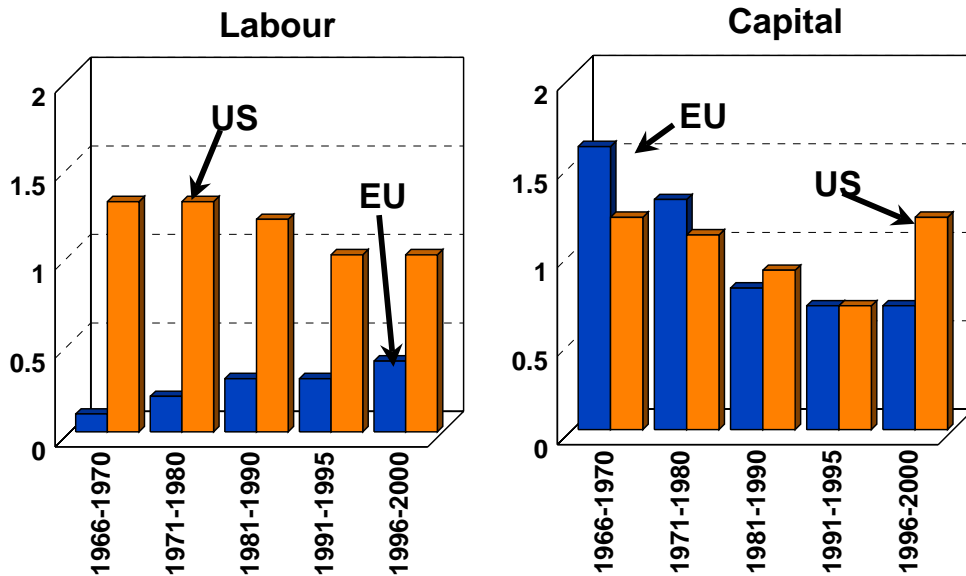


TABLE 13 : EU15	1966-1970	1971-1980	1981-1990	1991-1995	1996-2000
LABOUR POTENTIAL					
POPULATION OF WORKING AGE (Average Growth Rate)	0.4	0.7	0.7	0.4	0.2
TREND PARTICIPATION RATE	66.9	66.7	66.8	67.4	68.3
LABOUR FORCE (Average Growth Rate)	0.3	0.6	0.8	0.5	0.6
NAIRU *	2.3	4.3	7.9	9.2	9.4
POTENTIAL EMPLOYMENT (Average Growth Rate)	0.2	0.3	0.5	0.4	0.6
CAPITAL ACCUMULATION					
INVESTMENT (Average Growth Rate) **	5.1	1.6	2.6	0.0	4.2
CAPITAL STOCK (Average Growth Rate) **	4.6	3.7	2.3	2.1	2.1
MEAN AGE OF CAPITAL STOCK	15.1	14.2	15.1	15.7	16.1
INVESTMENT TO (POTENTIAL) GDP RATIO **	23.8	22.4	19.7	20.1	20.4
TECHNOLOGICAL PROGRESS					
TREND TFP (HP FILTER) (Average Growth Rate)	2.5	1.6	1.1	1.1	1.0
TREND TFP (VINTAGE METHOD) (Average Growth Rate)	2.6	1.7	1.0	1.1	1.2
- (AUTONOMOUS TFP COMPONENT(EXOGENOUS))	(1.5)	(1.5)	(1.5)	(1.5)	(1.5)
- (INDUCED TFP (ENDOGENOUS)) ***	(1.1)	(0.2)	(-0.5)	(-0.4)	(-0.3)
LABOUR PRODUCTIVITY (Average Growth Rate)****	4.3	2.9	1.9	1.8	2.0
CONTRIBUTIONS TO POTENTIAL GROWTH RATE					
LABOUR	0.1	0.2	0.3	0.3	0.4
CAPITAL ACCUMULATION	1.6	1.3	0.8	0.7	0.7
TFP*****	2.7	1.6	1.1	1.1	1.3
POTENTIAL GROWTH RATE	4.4	3.1	2.2	2.1	2.4

*For the period 1966-1980 the HP-filtered unemployment rate is used as a proxy for the NAIRU.

** While investment is quite volatile, the capital stock series (K) is relatively stable since annual net investment represents only a small proportion of K. It should also be noted that the investment to GDP ratio is calculated in real terms, and since it is assumed that investment goods prices have been falling rapidly over recent years, changes in the nominal investment to GDP ratio would consequently be very different. This is a particularly important point for assessing changes in the ratio over the 1990's when the prices of ICT goods declined sharply, with for example the real investment to GDP ratio in the US growing by 4.4% points between the first and the second parts of the decade compared with 2.7 in nominal terms. Likewise for the EU, the real increase was 0.3 compared with a nominal fall in the ratio of 0.5.

*** This is a residual term but in broad terms a negative figure indicates that the investment to GDP ratio is low relative to the presumed steady state value of the ratio or low relative to the level which would be consistent with the exogenous TFP component. By isolating this endogenous component one can see clearly that TFP is not independent of investment.

****Labour productivity is used here instead of labour augmenting technical progress which is the more correct technical term. In general terms the increase in labour productivity tends to be higher than that of labour augmenting technical progress since it includes an extra adjustment for the capital to labour ratio. This "premium" is likely to persist in the future as long as the capital intensity of production continues to rise.

***** This measures the contribution of TFP to potential growth and while normally there is a 1:1 relationship with trend TFP(vintage method) there are periods when small differences can emerge.

TABLE 14 : US	1966-1970	1971-1980	1981-1990	1991-1995	1996-2000
LABOUR POTENTIAL					
POPULATION OF WORKING AGE (<i>Average Growth Rate</i>)	1.7	1.7	0.9	0.9	1.0
TREND PARTICIPATION RATE	70.8	73.2	78.5	82.5	84.5
LABOUR FORCE (<i>Average Growth Rate</i>)	2.1	2.3	1.6	1.5	1.5
NAIRU *	4.7	6.4	6.6	5.7	5.5
POTENTIAL EMPLOYMENT (<i>Average Growth Rate</i>)	2.1	2.0	1.8	1.5	1.6
CAPITAL ACCUMULATION					
INVESTMENT (<i>Average Growth Rate</i>) **	2.1	3.8	2.9	4.2	9.6
CAPITAL STOCK (<i>Average Growth Rate</i>) **	3.4	3.1	2.5	2.1	3.6
MEAN AGE OF CAPITAL STOCK	14.6	14.7	15.2	15.8	15.6
INVESTMENT TO (POTENTIAL) GDP RATIO **	17.2	17.3	16.8	16.6	21.0
TECHNOLOGICAL PROGRESS					
TREND TFP (HP FILTER) (<i>Average Growth Rate</i>)	0.9	0.7	0.9	1.1	1.4
TREND TFP (VINTAGE METHOD) (<i>Average Growth Rate</i>)	0.9	0.7	1.0	0.9	1.6
-AUTONOMOUS TFP (EXOGENOUS)	(0.8)	(0.8)	(1.2)	(1.2)	(1.2)
-INDUCED TFP (ENDOGENOUS) ***	(0.1)	(-0.1)	(-0.2)	(-0.3)	(0.4)
LABOUR PRODUCTIVITY (<i>Average Growth Rate</i>)****	2.1	1.8	1.9	1.6	2.9
CONTRIBUTIONS TO POTENTIAL GROWTH RATE					
LABOUR	1.3	1.3	1.2	1.0	1.0
CAPITAL ACCUMULATION	1.2	1.1	0.9	0.7	1.2
TFP*****	0.9	0.7	1.0	0.9	1.7
POTENTIAL GROWTH RATE	3.4	3.1	3.1	2.6	3.9

*For the period 1966-1980 the HP-filtered unemployment rate is used as a proxy for the NAIRU.

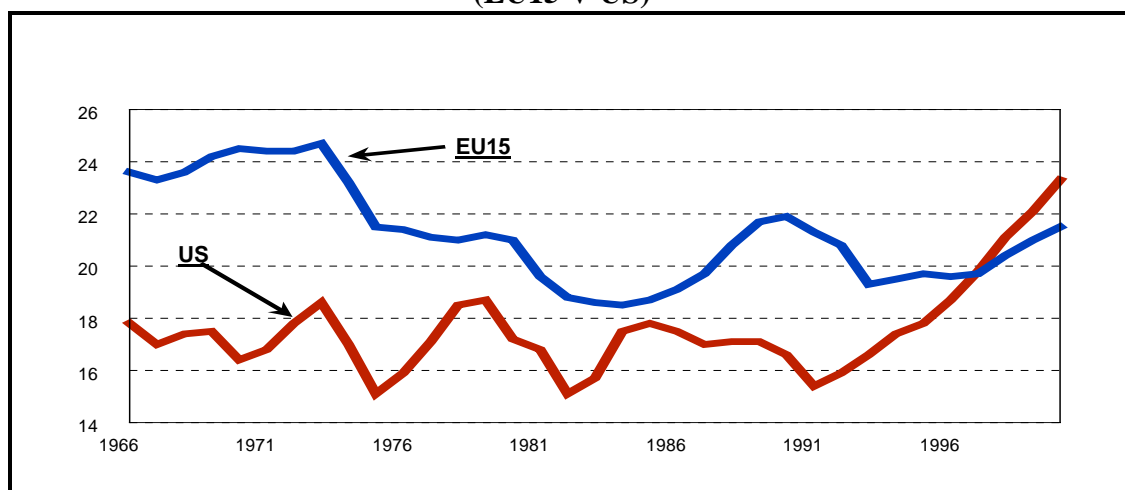
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*** This is a residual term but in broad terms a negative figure indicates that the investment to GDP ratio is low relative to the presumed steady state value of the ratio or with the level which would be consistent with the exogenous TFP component. By isolating this endogenous component one can see clearly that TFP is not independent of investment.

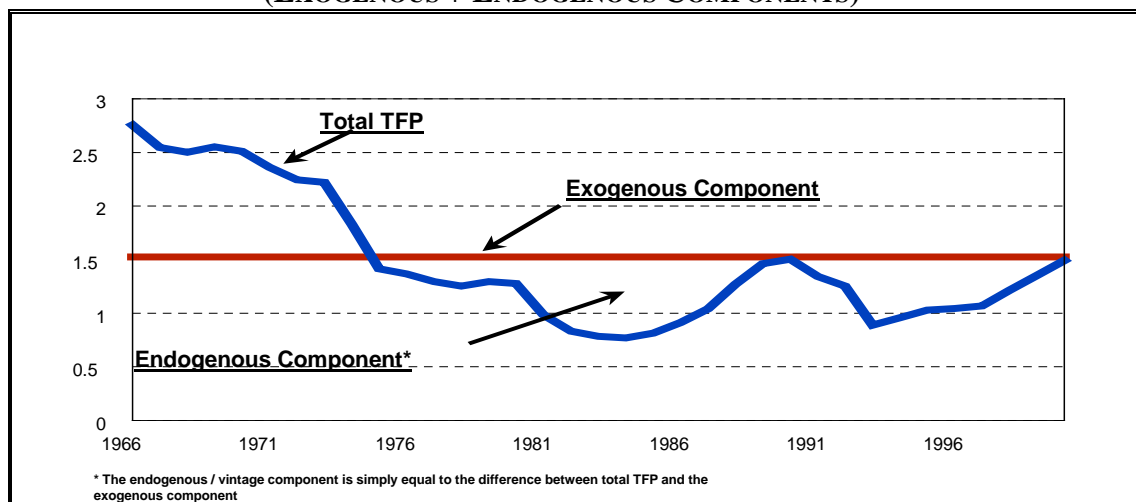
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*****This measures the contribution of TFP to potential growth and while normally there is a 1:1 relationship with trend TFP(vintage method) there are periods when small differences can emerge.

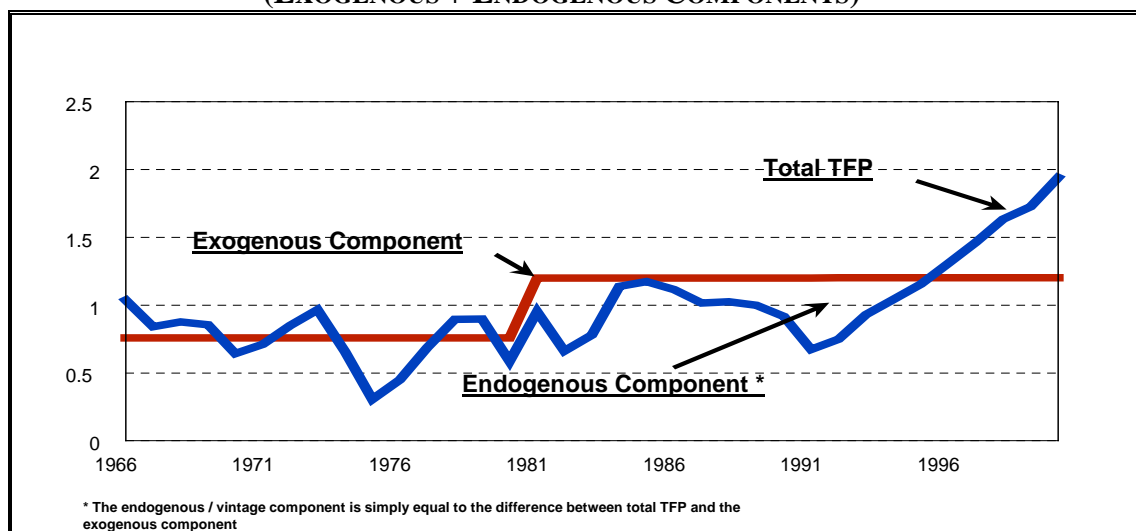
**GRAPH 23 : INVESTMENT TO GDP RATIO 1966-2000
(EU15 V US)**



**GRAPH 24 : EU15 : TFP GROWTH 1966-2000
(EXOGENOUS + ENDOGENOUS COMPONENTS)**



**GRAPH 25 : US : TFP GROWTH 1966-2000
(EXOGENOUS + ENDOGENOUS COMPONENTS)**



DETAILED ASSESSMENT OF THE SCENARIOS IN TERMS OF THE CONTRIBUTION TO GROWTH FROM LABOUR, CAPITAL AND TFP

As explained at the start of this section, the scenarios described below draw heavily on the "new economy" conclusions derived from Section 3. For this reason the main points to be retained from section 3 are repeated here:

- One of the key determining features of the TFP shock in the ICT sector is the price declines which it is provoking in terms of ICT investment goods. Given this productivity - investment link in the ICT TFP shock, one would expect to see, in the simulations given below, that both sources of TFP grow strongly at the same time i.e. both the exogenous and the endogenous, investment related, TFP components.
- The EU's potential growth rate is estimated to have been increased by "new " economy effects by about a $\frac{1}{4}$ of a % point over the second half of the 1990's compared with a gain of roughly $\frac{3}{4}$ of a % point for the US. In terms of composition, it was assumed in the case of the EU and the US that the bulk of the gains came via the investment channel, with in each case roughly $\frac{1}{3}$ of the gains coming via the production side and $\frac{2}{3}$ emanating from higher rates of investment⁴⁰.
- In terms of the long run growth rate effects of technological progress in the ICT sector it is estimated that the EU will experience a permanent increase in its growth rate of $\frac{1}{2}$ a percentage point with the US gaining 1 % point.

As one can see from tables 18 and 19 at the end of this section, these overall conclusions are incorporated into the central and optimistic scenarios, with the rate of TFP growth growing by 1 percentage point for the US between the pessimistic scenario (which is essentially a proxy for the 1991-1995 period) and the optimistic variants. In the case of the EU there is an acceleration in the rate of TFP growth of 0.7 of a % point, which is made up of the $\frac{1}{2}$ % point gain from "new" economy influences and an additional 0.2 of a % point boost to investment rates from the effects of introducing the structural reform agenda associated with the Lisbon strategy. In terms of composition, the 1% point boost for the US comes from both production and investment effects with a share of 40/60 which is broadly similar to the conclusions from section 3 regarding the second half of the 1990's, where the breakdown was roughly $\frac{1}{3}$ production and $\frac{2}{3}$ investment. While the optimistic scenario for the US includes an assumption of an investment rate which is similar to the second half of the 1990's, assuming continuing investment price declines, this would be equivalent to a decline in nominal terms for the investment ratio. In this regard, the central scenario shows a fall in both nominal and real terms in the investment to GDP ratio in the US which better reflects the sustainability concerns of the authors with regard to the US investment trends of the late 1990's. With regard to

⁴⁰ It is important to stress that these conclusions from section 3 are not fully reflected in the historical data given in Tables 13 and 14 which give a breakdown of trend TFP into its exogenous and endogenous components. On the basis of these figures the trend TFP increases over the second half of the 1990's have emanated entirely from the capital accumulation side in both the US and the EU, with insufficient evidence to definitively warrant the inclusion of an exogenous trend break in either area over this period. While a break is not found in the macro data for the US and the EU, this does not of course mean that it has not occurred in the ICT sector because of the normal offsetting movements between expanding and declining sectors and because of the well known measurement difficulties in the overall tertiary sectors of both these economies. This uncertainty concerning the source of the recent trend TFP growth is clearly reflected in the scenarios, with the view that there has been no trend break in exogenous TFP being in fact incorporated in the pessimistic scenarios for both the EU and the US. The section 3 view of a trend break is incorporated only in the central and optimistic scenarios for the US and only in the optimistic scenario for the EU.

the ½ % boost to the EU growth rate from the "new" economy, 0.2 is in the form of a trend break in the rate of autonomous technical progress and 0.3 comes through via the investment channel.

PESSIMISTIC SCENARIO

- **LABOUR POTENTIAL** : In the case of the EU, the latest Eurostat population projections suggest an average annual increase in the working age population of 0.1% over the period 2001-2010 with the equivalent UN forecast figures for the US being substantially higher at 1%. In terms of participation rates, the EU15 rate is expected to fall back from a rate of about 68 ½ % over the last number of years to 68 % and in the US the rate reverts back to the average for the 1990's as a whole. As the NAIRU figures for both the US and the EU are assumed to stay at their estimated 2000 rates, the knock on effect of all the above assumptions is that potential employment is forecast to show no overall growth in the EU over the period but to grow by an annual 0.6 of a % point in the US.
- **CAPITAL ACCUMULATION** : In terms of investment, the assumption in both areas is that the investment to GDP ratio will fall relative to recent levels, with the EU reverting to the average levels seen over the period 1991-1995 i.e. around 20 % of GDP and with the US falling back to 18 ½ % of GDP. While this latter rate for the US is low relative to the 21% average achieved over the period 1996-2000, it is still nearly two percentage points higher than in the first half of the 1990's. In terms of capital stock developments both areas are expected to grow by about two percent annually over the period thereby resulting in similar contributions to growth from the capital accumulation side.
- **TFP** : As explained earlier the pessimistic scenario assumes that there has been no fundamental change in the functioning of either the EU or US economies over the last number of years, with any productivity gains which were registered been either cyclical or sector-specific in origin. Under this view the efficiency gains achieved in the ICT sector will not endure and any investment in the products of this sector will not produce the hoped-for TFP boost i.e. the TFP spillover effects from the ICT sector on the rest of the economy will be zero.

Consequently, to accommodate this view in the scenario, annual average rates of TFP growth have had to be reduced in the US from the 1.6 % achieved over the period 1996-2000 to a rate of 0.9 % which was the average for 1991-1995. Since the rate of autonomous technical progress is assumed not to have changed relative to the second half of the 1990's, this downturn in TFP growth is achieved by a reduction in the investment to GDP ratio. One interesting feature of the scenario for the US is the high levels of the investment to GDP ratio which the maintenance of the early 1990's TFP rates would entail, which could imply that over the period 1991-1995 that there had been an autonomous increase in technical progress over and above that which would be consistent with normal investment to GDP rates. While some evidence to support this was found, the extent was rather minor. In the case of the EU the pessimistic scenario assumes a small decline in the rate of TFP growth over the next 10 years relative to the years 1996-2000, with the rate falling from 1.2 % to 1.1 %. As in the US this TFP

decline is catered for in the scenario by a small fall in the investment to GDP ratio.

- **OVERALL POTENTIAL GROWTH RATE** : As Table 15 indicates, the pessimistic scenario for the period 2001-2010 predicts an annual average growth rate of 1 ¾ % for the EU and 2% for the US.

TABLE 15 : PESSIMISTIC GROWTH SCENARIO FOR EU15 AND US (2001-2010)		
CONTRIBUTIONS TO GROWTH FROM EMPLOYMENT, CAPITAL STOCK AND TFP		
	PESSIMISTIC SCENARIO	
	EU15	US
LABOUR	0.0	0.4
CAPITAL ACCUMULATION	0.7	0.7
TFP	1.1	0.9
ANNUAL AVERAGE POTENTIAL GROWTH RATE	1.8	2.0

CENTRAL SCENARIO

- **LABOUR POTENTIAL** : With the working age population assumptions not changing for any of the three scenarios, the average labour force growth rate in the EU of 0.3% a year, assumed in the central scenario, is driven by a 1 ½ % points increase in the participation rate to 69 ½ % of the 15-64 year old age group, which represents an increase of 2 ¼ percentage points relative to the first half of the 1990's. This boost to the labour supply is reinforced by an average 1 percentage point fall in the NAIRU from 9 ½ % in 2000 to 8 ½ % over the period 2001-2010. This 1% point average fall would result in the achievement of a NAIRU of about 7½ % in 2010. With regard to the US, given the already low level of the NAIRU and the fact that participation rates are currently over 15 percentage points higher than in the EU, the central scenario simply leaves the NAIRU unchanged at its 2000 rate and broadly extrapolates forward the average participation rates for the second half of the 1990's. The combined impact of the participation rate and NAIRU assumptions for both areas has the effect of increasing potential employment in the EU and the US by ½ and ¾ of a % point each year respectively over the simulation horizon.
- **CAPITAL ACCUMULATION** : In the case of the EU, the growth rate of the capital stock in the year 2000 is extrapolated forward for the forecast period, representing an annual average growth of 2 ½ % over the next 10 years. This rate of capital accumulation is about 0.3 of a % point higher than the average of the period 1996-2000 and would involve the maintenance of an investment to GDP ratio in the EU at the relatively high rate of around 21% of GDP. While capital accumulation in the US is expected to grow at a faster pace than in the EU, the forecasted annual average growth of 3% over the simulation period still represents a slowdown compared with recent experience in the US, with the capital stock growing by 3 ½ % on average over the years 1996-2000 and by nearly 4 ½ % in the year 2000 itself. While an assumption for the US of 3 % growth in the capital stock may

consequently appear excessively cautious given these recent developments, it should be remembered that this rate of capital accumulation implies an average investment to GDP ratio of over 20% of GDP each year over the period 2001-2010, which is roughly 3 ½ % points higher compared with both the 1980's and the first half of the 1990's.

- **TFP**: The assumptions for the EU and US in terms of possible "new" economy effects on potential growth draw heavily, as already stated, on the analysis contained in Section 3. As explained at the outset, the central scenarios for both geographical areas give the benefit of the doubt to the belief that the long term growth pattern may have been altered over recent years due to massive productivity gains in the ICT sector and the associated investment stimuli. The scenario assumes that these gains will persist, at least partially, over the coming decade either in the form of further efficiency gains in the ICT sector or via investment / spillover effects from this sector to the rest of the economy. In the case of the EU, the central scenario described in section 3 assumed TFP increases in the EU's ICT sector of roughly one third that of the US over the next 40 years implying that the overall growth rate in the EU would be 0.3 of a % point higher in 2005 rising to 0.4 in 2010 and 0.5 in 2030-2040. These assumed ICT-related impulses to growth, combined with a small, investment related, TFP boost from the labour market reform process referred to earlier, results in an assumed average boost to TFP over the next 10 years of 0.4 of a % point. As Table 18 makes clear this boost to growth comes via the endogenous route of increased levels of gross fixed capital formation.

In the case of the US, the "new" economy simulations in section 3 pointed to a possible average boost to TFP growth of roughly 1 % point over the next 10 years. However, as one can see from Table 19, the central scenario assumes only a boost of ½ a % point, with over half of that latter boost coming in the form of an autonomous TFP shock emanating from the ICT sector (i.e. a structural break) and with the remainder coming via the associated investment impulse which is driven by declines in the prices of ICT investment goods. Given the close link between the productivity gains in the ICT sector and the subsequent investment boost, alluded to earlier, one could reasonably question an assumption where the investment to GDP ratio in the US would fall over the simulation period compared with the average achieved for 1996-2000. While such concerns are not groundless it was nevertheless felt that it would not be prudent to assume a continuation of the investment levels of this latter period given the clear sustainability worries, in our view, as witnessed by the large deterioration in terms of private sector financial balances over the last number of years and the fact that the investment to GDP rate of 20¼ % of GDP, which was used in the central variant, compares with annual averages of 17 ¼ percent in the 1960's and 1970's and 16 ½ - 16 ¾ over the period 1980-1995. Because of the unprecedented nature of the present investment levels (even if one allows for the influence of falling investment prices) and the emerging sustainability concerns, an assumption of over 20% for the investment to GDP ratio in the US does not appear unduly negative.

- **OVERALL POTENTIAL GROWTH RATE**: In terms of the overall growth rate, the central scenario for the period 2001-2010 predicts an annual average growth rate of 2 ¾ % for the EU and 3 % for the US. These rates of change represent an

increase of about a ¼ of a % point in the EU's growth rate compared with the second half of the 1990's but a fall of close to 1% point for the US with reference to the same period.

TABLE 16 : CENTRAL GROWTH SCENARIO FOR EU15 AND US (2001-2010)		
CONTRIBUTIONS TO GROWTH FROM EMPLOYMENT, CAPITAL STOCK AND TFP		
	CENTRAL SCENARIO	
	EU15	US
LABOUR	0.3	0.5
CAPITAL ACCUMULATION	0.9	1.0
TFP	1.5	1.5
ANNUAL AVERAGE POTENTIAL GROWTH RATE	2.7	3.0

OPTIMISTIC SCENARIO

As with the two previous scenarios, the optimistic variant for the EU and for the US are again underpinned by "new" economy and, in the case of the EU, labour market reform assumptions. In the case of the US, it is assumed that the conclusions from section 3 regarding the growth impulse from TFP increases in the ICT sector will be fully realised. In fact, compared with the central scenario, this "new" economy boost makes up the full ½ % point increase in the US growth rate from 3 to 3 ½ %. In the case of the EU, compared with the central scenario, both "new" economy and additional, substantial, labour market reforms are assumed, with both sets of growth impulses being driven by the objectives set out in the much heralded "Lisbon" strategy.

- **LABOUR POTENTIAL** : As alluded to above, the assumptions for the US in terms of participation rates and levels of structural unemployment do not change relative to the central scenario. In the case of the EU, however, potential employment levels are boosted considerably through both further increases in participation rates to well over 70% of the working age population and with the NAIRU falling to an average rate of 7 ½% over the period and coming very close to present US NAIRU rates by the end of the forecast period in 2010. In terms of the employment rate, which is the reference indicator suggested in the Lisbon conclusions, while the Lisbon objective of 70% is not attained in the optimistic variant, the employment rate does climb from less than 62 % under the pessimistic scenario to 65 ¼ % in the present exercise.

While the objective of 70% is of course achievable, it may be difficult over one decade to do so given that the optimistic scenario already assumes that the EU's NAIRU rate falls to close to US levels. Given the assumed low level of the NAIRU, achieving a 70% employment rate by 2010 would in fact require an additional boost to participation rates of over 5% points, which if historical comparisons are any indication would be difficult to realise. As table 13 demonstrates, trend participation rates in the EU, unlike NAIRU levels, have been remarkably stable over the last 35 years with the average over the period 1966-

1990 being of the order of 67% and with the 1990's witnessing a small increase in the trend to 68%. However, as the experience of the US, shown in Table 14, makes clear it is not impossible to achieve substantial increases in labour supply via this route, with US participation rates growing by nearly 14% points over the equivalent period 1966-2000.

Finally, it should be noted that increasing EU participation rates by over 5 percentage points, compared with the present assumption, would boost labour's total contribution to growth from the assumed 0.6 of a % point which underlies the present optimistic scenario to between 1 ¼-1 ½ percentage points. To put this latter estimate into perspective, labours' contribution to EU growth over the 1960's and 1970's was between 0.1-0.2 of a % point and over the 1980's and 1990's 0.3-0.4. Compared with this historical pattern, the assumption in the optimistic scenario of a contribution of 0.6 from labour does not appear unreasonable. Of course, if national policy makers introduce the wide sweeping labour market reforms which the full realisation of the Lisbon strategy would entail, including the associated taxation and social welfare changes, this would of course be very welcome in terms of additional growth, adding, as it would, an average ¾ of a % point to the growth rate over the period thereby pushing the EU's annual average rate from 3 ½ % to 4 ¼ % for the next 10 years.

- **CAPITAL ACCUMULATION** : For the EU, the optimistic scenario entails a further boost to the investment to GDP ratio i.e. an additional 1 % point compared with the central scenario. This would entail a sustained rate of growth of around 4 % a year in gross fixed capital formation over the next 10 years which appears achievable when compared with the average of 4 ¼ % realised between 1996-2000 and over 5% in the year 2000 itself. With capital formation growing at these rates, the EU's capital stock would register a 3% annual average performance over the 10 years, with the effect that capital accumulation would contribute over 1 percentage point to the overall growth rate over the period. For the US, despite the sustainability concerns referred to in the central scenario, it is assumed in the present scenario that the US investment to GDP ratio can continue to grow at the rates seen in the second half of the 1990's i.e. 21%. This additional investment drive is, as explained earlier, linked to the nature of the TFP shock which is taking place.
- **TFP** : On the assumption that the "new" economy effects come through as expected and that the Member States act to introduce the type of measures underpinning the Lisbon objective of transforming the EU into a world beating economic powerhouse, the TFP figures underlying the optimistic scenario for the EU seem achievable. As can be seen in Table 18, the optimistic scenario assumes a break with the past in terms of autonomous TFP growth, with an ICT-related increase of 0.2. While such structural breaks in the long run pattern of exogenous technical progress have occurred in the US in the 1980's and perhaps the 1990's, this would be the first time in decades that this has arisen in the EU⁴¹. In addition

⁴¹ This degree of long run stability in labour augmenting technical progress is not that surprising given the normal offsetting effects from expanding and declining sectors. What is perhaps surprising is that the EU has been able to keep this labour augmenting exogenous rate at the relatively high annual rate of 2 ¼% (i.e. 1.5% trend TFP growth divided by labour's income share of roughly .65 translates into growth in labour augmenting technical progress of 2 ¼%) over a period of decades where one could credibly have assumed a decline as a result of the long term sectoral shift towards the relatively low productivity service sectors.

to this "new" economy break, there is also the associated investment impulse from the ICT production effects and also from implementing such a comprehensive structural reform programme as represented by the Lisbon agenda. The combined impact of both the autonomous and endogenous TFP components (with new investment as the vehicle for introducing, efficiency enhancing, ICT and other technologies), would have the effect of boosting potential growth by 0.3 of a % point over the next ten years.

In the case of the US, with the investment to GDP ratio moving up relative to the central scenario and with a small additional boost to exogenous TFP, there is an assumed ½ % point increase in TFP growth over the period. The small additional autonomous acceleration in technical progress could be interpreted as spillover effects in the non-ICT sectors from investing in productivity enhancing ICT technologies. The overall gain of ½ a % point in terms of the acceleration in TFP is also consistent with the conclusion of section 3 that relative to the average of the period 1991-1995 the US could gain up to 1% point on its overall growth rate from both the direct production effects from the ICT sector and the indirect investment / spillover contributions. With the investment to GDP ratio being kept at its average 1996-2000 level, the optimistic scenario therefore implicitly assumes that benefits start to accrue from the heavy ICT investments which have already taken place and from ongoing quality improvements in the type of investment which is expected to occur over the simulation horizon.

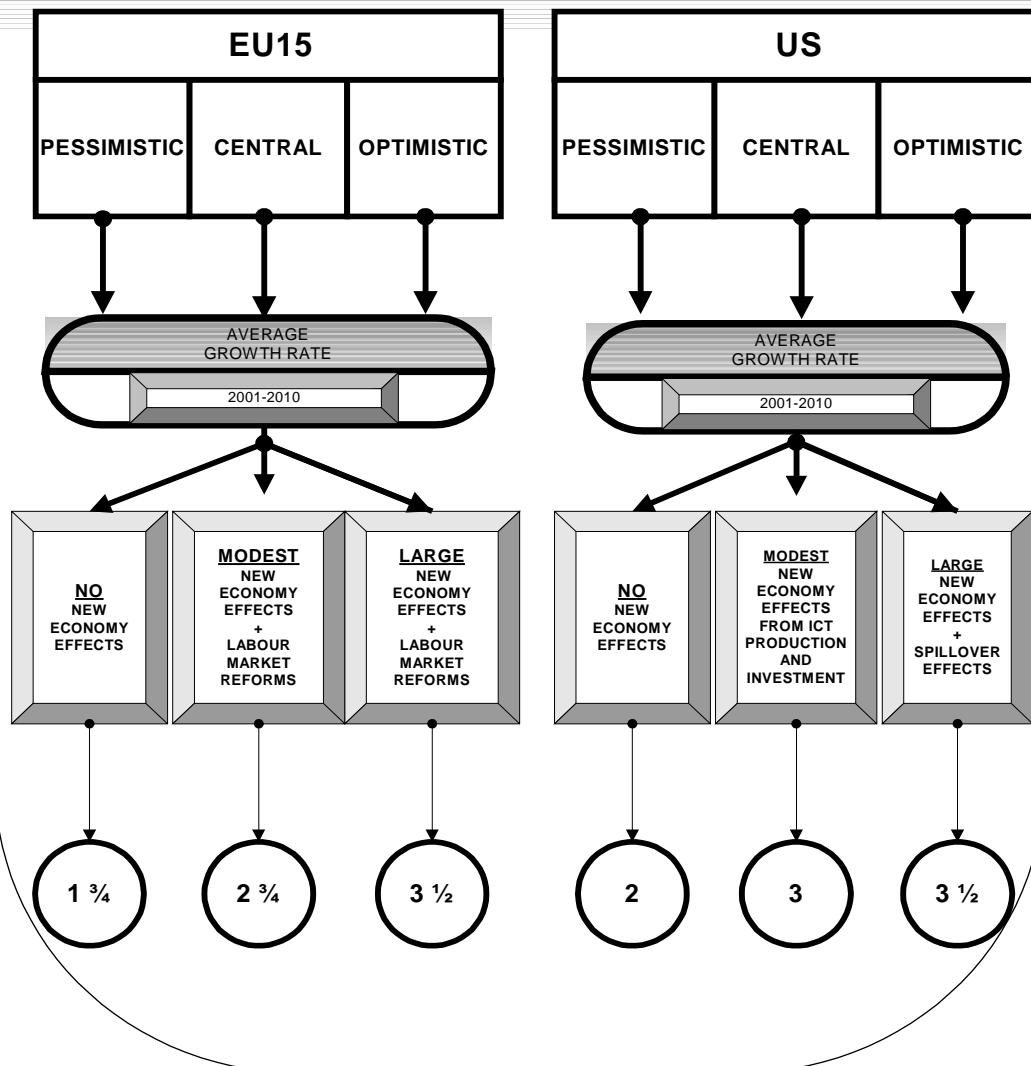
- **OVERALL POTENTIAL GROWTH RATE** : In overall terms, the optimistic scenario for the period 2001-2010 suggests than an annual average growth rate of 3 ½ % is possible for both the EU and the US. For the EU this rate of increase would constitute a significant break with past trends, with similarly high, sustained, rates of growth only been achieved in the 1960's and in the early years of the 1970's. However, if national governments act decisively to implement the Lisbon proposals, such rates of growth are possible given both the availability of a large, presently underutilised, labour reserve in the Community and the opportunities emerging in a growing number of both new and maturing high productivity industries.

TABLE 17 : OPTIMISTIC GROWTH SCENARIO FOR EU15 AND US (2001-2010)		
CONTRIBUTIONS TO GROWTH FROM EMPLOYMENT, CAPITAL STOCK AND TFP		
	OPTIMISTIC SCENARIO	
	EU15	US
LABOUR	0.6	0.5
CAPITAL ACCUMULATION	1.1	1.1
TFP	1.8	1.9
ANNUAL AVERAGE POTENTIAL GROWTH RATE	3.5	3.5

TABLE 18 : EU15 SCENARIOS 2001-2010	PESSIMISTIC	CENTRAL	OPTIMISTIC
LABOUR POTENTIAL			
POPULATION OF WORKING AGE (<i>Average Growth Rate</i>)	0.1	0.1	0.1
TREND PARTICIPATION RATE	68.0	69.6	70.4
LABOUR FORCE (<i>Average Growth Rate</i>)	0.0	0.3	0.5
NAIRU	9.4	8.4	7.4
POTENTIAL EMPLOYMENT (<i>Average Growth Rate</i>)	0.0	0.5	0.9
CAPITAL ACCUMULATION			
INVESTMENT (<i>Average Growth Rate</i>)	0.7	2.4	4.0
CAPITAL STOCK (<i>Average Growth Rate</i>)	2.0	2.5	2.9
MEAN AGE OF CAPITAL STOCK	16.5	16.3	16.0
INVESTMENT TO (POTENTIAL) GDP RATIO	20.2	21.1	22.0
TECHNOLOGICAL PROGRESS			
TREND TFP (VINTAGE METHOD) (<i>Average Growth Rate</i>)	1.1	1.5	1.8
-AUTONOMOUS TFP (EXOGENOUS)	(1.5)	(1.5)	(1.7)
-INDUCED TFP (ENDOGENOUS)	(-0.4)	(0.0)	(0.1)
LABOUR PRODUCTIVITY (<i>Average Growth Rate</i>)	1.8	2.4	2.9
CONTRIBUTIONS TO POTENTIAL GROWTH RATE			
LABOUR	0.0	0.3	0.6
CAPITAL ACCUMULATION	0.7	0.9	1.1
TFP	1.1	1.5	1.8
POTENTIAL GROWTH RATE	1.8	2.7	3.5

TABLE 19 : US SCENARIOS 2001-2010	PESSIMISTIC	CENTRAL	OPTIMISTIC
LABOUR POTENTIAL			
POPULATION OF WORKING AGE (<i>Average Growth Rate</i>)	1.0	1.0	1.0
TREND PARTICIPATION RATE	83.6	84.2	84.2
LABOUR FORCE (<i>Average Growth Rate</i>)	0.6	0.8	0.8
NAIRU	5.4	5.4	5.4
POTENTIAL EMPLOYMENT (<i>Average Growth Rate</i>)	0.6	0.8	0.8
CAPITAL ACCUMULATION			
INVESTMENT (<i>Average Growth Rate</i>)	-2.7	0.3	1.3
CAPITAL STOCK (<i>Average Growth Rate</i>)	2.1	3.0	3.4
MEAN AGE OF CAPITAL STOCK	15.5	15.0	14.9
INVESTMENT TO (POTENTIAL) GDP RATIO	18.4	20.2	21.0
TECHNOLOGICAL PROGRESS			
TREND TFP (VINTAGE METHOD) (<i>Average Growth Rate</i>)	0.9	1.4	1.9
-AUTONOMOUS TFP (EXOGENOUS)	(1.2)	(1.5)	(1.6)
-INDUCED TFP (ENDOGENOUS)	(-0.3)	(-0.1)	(0.3)
LABOUR PRODUCTIVITY (<i>Average Growth Rate</i>)	1.6	2.5	3.0
CONTRIBUTIONS TO POTENTIAL GROWTH RATE			
LABOUR	0.4	0.5	0.5
CAPITAL ACCUMULATION	0.7	1.0	1.1
TFP	0.9	1.5	1.9
POTENTIAL GROWTH RATE	2.0	3.0	3.5

**DIAGRAM 10 : OVERVIEW OF THE GROWTH
SCENARIOS FOR THE EU15 + US
2001-2010**



OVERALL ASSESSMENT OF GROWTH OUTLOOK FOR EU AND US

In conclusion therefore it would appear, from the analysis in this section, that the production function generated 2 ¾ % potential growth rate indicated for 2000 for the EU does indeed seem justifiable as an indication of sustainable output growth in the Community over the medium to long run. This rate of growth in fact constitutes the central scenario assumed for the EU over the next 10 years and is dependent, for its realisation, on movement along a policy path which is broadly consistent with the Lisbon strategy. The policy initiatives to flow from this strategy should ensure the emergence of, at a minimum, both modest "new" economy growth effects throughout all the Member States and better functioning labour markets. If the strategy is implemented with the appropriate degree of zeal on behalf of policy makers, the optimistic scenario foresees the possibility of growth gains of the order of 3 ½ % on an annual average basis over the simulation horizon.

In the case of the US, however, the production function estimated potential output figure of 4½ % indicated for 2000 is, in our view, not sustainable, not because of a fundamental rethink in terms of the "new" economy but more because of the associated investment implications. Given current levels of domestic debt and unsustainably large balance of payments deficits, it is highly questionable whether the US can maintain the large boost in their levels of capital accumulation which has been such a key feature of developments over the last 2-3 years. Our central view is that the investment to GDP ratio will fall back to a rate of around 20%, a rate which is still some 3 ½ percentage points above that of the early 1990's and that of the 1980's. In these circumstances, the central estimate for the long run rate of growth in the US for the next 10 years is 3%, which is substantially below the "technical capacity" indication of 4 ½ % for 2000. The example of the US is important in underlying the need to carefully scrutinize the underlying determinants of growth as opposed to the unquestioning acceptance of model based estimates. The production function / growth accounting framework is a useful analysis tool but one which must be accompanied by a considered evaluation of all the pertinent contributory factors.

SUMMARY AND CONCLUDING REMARKS

SUMMARY AND CONCLUDING REMARKS

SHORT OVERVIEW OF PAPER : This paper provides a comprehensive analysis of past trends and future prospects in relation to potential output growth in the EU15 and the US. Following an examination of the various statistical trend estimation methods, which expressed a preference for the HP filter method, and a presentation of the economic based production function methodology, estimates were provided using both these approaches for potential output and output gap developments for the period 1981-2000. On the basis of these calculations, while it was clear that the US had experienced a substantial upturn in its underlying rate of growth over the second half of the 1990's, less certainty could be attributed to the trend growth path for the EU. While both the HP filter and Production Function (PF) methods both pointed to an improvement in recent years in the EU, the PF method appeared to be suggesting a more "rosy" scenario. However, as made clear in section 2, the relative optimism of the PF method rested to a large extent on the use of the "vintage" method for measuring the trend TFP component, whereas if one used a simple HP filtered estimate of trend TFP the potential growth rate would be $\frac{1}{2}$ a percentage point lower.

Due to the large discrepancy in the growth estimates depending on the approach adopted regarding the modelling of TFP, and given the uncertainty attached to the "vintage" method in that it may be failing to adequately remove the effects of the cyclical upturn in the EU in the late 1990's, it was felt important to cross check the TFP and overall growth results produced by this method through :

- **firstly**, examining the available evidence in terms of "new" economy influences on growth in both the EU and the US to see whether the latter could be responsible for the upturn in potential growth calculated by the "vintage" method. From the analysis in section 3 of the paper, it would appear that the EU's potential growth rate has indeed been boosted by ICT production and investment effects by about a $\frac{1}{4}$ of a percentage point over the second half of the 1990's compared with an acceleration of $\frac{3}{4}$ of a % point in the US.
- **secondly**, the results were also cross-checked by assessing whether the potential output estimates for the US and the EU in 2000 will be sustained over the next 10 years. In the case of the EU, it would appear that the production function generated $2\frac{3}{4}$ % potential growth rate indicated for 2000 does seem justifiable as an indication of sustainable output growth in the Community over the medium to long run. In the case of the US, however, the production function estimated potential output figure of $4\frac{1}{2}$ % which is indicated for 2000 is, in our view, not sustainable, with the central estimate for the long run rate of growth in the US for the next 10 years being set at 3%. The example of the US is important in stressing the need to carefully scrutinize the underlying determinants of growth as opposed to the unquestioning acceptance of the estimates from the growth accounting framework underpinning the production function method.

DETAILED SUMMARY OF KEY POINTS

While the above text provides a short overview of the main thrust of the paper, this is hardly sufficient given both the comprehensive and the often technically complex nature of the issues being discussed. Consequently, a detailed summary is provided

below including the key points to be retained from each of the four sections, with some concluding remarks at the end to round off the discussion.

MEASUREMENT OF POTENTIAL OUTPUT : STATISTICAL V ECONOMIC APPROACHES

1. STATISTICAL TREND ESTIMATION METHODS

- While the various statistical methods discussed in section one differ at a technical level in terms of the estimation procedures used and in terms of the identifying assumptions made, these differences are not as pronounced at the level of the actual trend output figures produced. Given the broad comparability in terms of trend output and the confusion which multiple estimates would generate, it was decided to pick one method which would be reasonably typical of the statistical group of trend extraction methods as a whole.
- Following an analysis of the main statistical methods used for trend estimation, such as the HP and Band Pass Filters, the linear time trend, the Kalman Filter approach as well as univariate and multivariate Beveridge Nelson and the Blanchard and Quah decomposition, it was concluded, all things considered, that the HP filter shared many of the features of the other statistical methods and that it produced acceptable trend output results for both the EU and the US.
- However, since it is accepted that the "true" trend and cycle components of a series can never be deciphered, it is not of course possible to definitively establish any one detrending method as being superior. All this section wished to confirm was that the HP filter operates equally as well as all other possible methods, and in many cases even better, and that it could be regarded as a good example of a statistical trend estimation method. The fact that the HP filter is widely used by both academic researchers and in various policy making institutions was clearly an additional factor in its ultimate selection.
- Finally, in terms of the practical application of the HP filter method in section 2 of this paper, the choice of smoothing parameter and the number of additional observations added on at the end of the series to correct for the well known "end point" bias problem conform to the standard approaches adopted in the literature on both these issues.

2. ECONOMIC BASED ESTIMATION METHODS : THE PRODUCTION FUNCTION APPROACH

- A standard neoclassical production function is used which is the preferred conceptual approach adopted by international (OECD and IMF) and national organisations.
- **CALCULATION OF LABOUR POTENTIAL** : Potential employment is generated from a smoothed labour force series which has been generated by applying a HP filtered participation rate to the working age population figures. With the smoothed participation rate leading to a relatively stable labour force series, the potential employment series is then set equal to the labour force minus the NAIRU estimates for the EU and the US. A structural approach is adopted to estimating the NAIRU.
- **CAPITAL STOCK** : Since the capital stock is the best indicator of the technical capacity of an economy at any point in time, there is no justification to smooth this series in the production function approach. The unsmoothed series is not as

erratic as one may expect since although investment is very volatile the contribution of capital to growth is quite stable since net investment in any given year is only a tiny fraction of the capital stock figures.

- **TFP** : The "vintage" approach is used to decompose TFP into a trend and a random component, with past movements in technical progress / TFP being linked to changes in the average age of the capital stock. This "vintage" method is the main distinguishing feature of the production function approach presented in this paper. It differs significantly compared with the TFP trend extraction approaches adopted by other international institutions such as the OECD and the IMF. It has been adopted both for pragmatic data availability reasons and since the specification seems to explain well the long-run movements of TFP in nearly all EU countries as well as in the US. In addition, vintage models are particularly useful for long term analysis involving the interaction of investment, technical progress and potential output (with new investment as the vehicle for introducing, productivity-enhancing, new technologies).
- Finally, one needs to ask what is the relevance of potential output estimation for policy analysis. In particular, what can the production function framework contribute in terms of answering questions concerning the growth potential in Europe and the US ?. In our view it essentially provides a coherent accounting framework that links a technical input-output scheme with stock flow relationships. These latter relationships in turn link investment with changes in both the overall capacity and efficiency of the respective economies.

3. CLEAR PREFERENCE IN THE TEXT FOR RETAINING BOTH THE STATISTICAL HP FILTER AND ECONOMIC-BASED PRODUCTION FUNCTION METHODOLOGIES FOR POTENTIAL OUTPUT AND OUTPUT GAP ANALYSIS PURPOSES

- An objective comparison between the HP filter and production function methods is not possible given differences in both underlying methodologies and in the widely varying end purposes to which policy analysts employ the various methods. A clear trade-off exists between the operational simplicity of the HP filter and the economic content of the production function method.
- Retaining the two methods for overall policy evaluation and surveillance does not stop policy makers expressing a preference for using only one of the two methods for specific operational needs, such as, for example, calculating structural budget balances.
- In terms of the respective empirical performance of both methods, the overriding conclusion is that both the HP and Production Function methods have advantages and disadvantages and that from a wider policy perspective both methods should be retained since they can both provide useful, complementary, information which is of interest to policy makers
- There is no justification for believing that one method is superior. While the Production Function method is clearly more economically respectable and perhaps following proper detailed analysis may prove superior to the HP filter in many practical applications, it must be reiterated that the calculation of potential output is dogged by the fact that it is unobserved and so must be calculated, with all the

attendant problems and judgemental choices to be made in the latter estimation process⁴².

POTENTIAL OUTPUT AND OUTPUT GAP ESTIMATES FOR EU15 AND US

4. POTENTIAL OUTPUT ESTIMATES

- **EU** : Both the HP filter and PF methods suggest that a small acceleration of potential output growth has taken place in the EU over recent years and that this improvement is likely to continue beyond the year 2000. In terms of period averages, both the statistical and economic methods point to an acceleration of the order of a $\frac{1}{4}$ of a % point in the EU's underlying growth rate from an annual average rate of around 2 $\frac{1}{4}$ % over the period 1991-1995 to about 2 $\frac{1}{2}$ % for 1996-2000. In terms of more recent developments and the short term outlook, the HP approach suggests a potential growth rate of 2.6% in 2000, with little change expected over the period to 2002. The production function method is more optimistic and gives a growth rate of potential output of 2.8% in 2000 with an increase to 3% predicted for 2002.
- **US** : In the case of the US, the HP filter and PF methods both indicate an increase in the underlying pace of growth in the second half of the 1990's but the PF method is clearly more optimistic. In terms of period averages, the PF method suggests that the US's potential growth rate has risen by 1 $\frac{1}{4}$ % points between the first and second halves of the 1990's whereas the HP filter suggests a much more modest improvement of $\frac{1}{2}$ a % point. In terms of individual year figures, the PF method produces an estimate of 4 $\frac{1}{2}$ % for potential growth in 2000 compared with slightly less than 4% for the period 1996-2000 as a whole. The HP filter estimate for both 2000 and for the 1996-2000 period average is identical at 3 $\frac{3}{4}$ %.
- **CONTRIBUTIONS TO GROWTH IN THE EU AND THE US** : When comparing the growth contributions of labour, capital and TFP in the EU over the last two decades compared with the experience of the US over the same period, there are striking differences. The US boom in the 1990's is evidently driven by capital formation and an acceleration of TFP, with the contribution of labour to growth remaining constant, compared to the 1980's. The figures for Europe are less impressive in terms of the overall growth rate acceleration and the compositional changes are also different to that of the US. While positive growth signs are emerging in Europe these must be kept in perspective, with even the most recent accelerations in the growth rate of TFP and the capital stock being on a much lower scale compared to those experienced in the US over the same period. With regard to labour productivity trends, the US has experienced an increase of nearly 1 $\frac{1}{4}$ % points between the first and second halves of the 1990's, to reach an annual

⁴² **POLICY MAKERS NEED TO UNDERSTAND THE TRADE-OFFS INHERENT IN BOTH APPROACHES** : While purely statistical measures have definite advantages in terms of both their ease of application and their limited information requirements they are nevertheless not without shortcomings. In general, purely statistical filters need to be symmetric and therefore they have an end point bias problem that is especially important for policy making institutions which are predominantly concerned with the most recent evolution of economic time series. In addition, purely statistical methods usually reveal little about possible economic mechanisms generating certain trends and trend projections based on these methods have to rely entirely on past information. In contrast, the production function method provides a convenient framework to decompose economic trends into demographic, labour market, investment and technological components and it offers an analytical framework for making simple projections. An unavoidable shortcoming of this method is however the limited data quality and availability which only allows for the formulation of relatively crude models of the economy. Consequently, the inherent strengths and weaknesses of both methods need to be understood and allowed for. Any preference for one or the other method, at any particular point in time, will largely be dictated by periodic evaluations of the empirical supporting evidence and of the policy question or domain to be examined.

average rate of nearly 3% for the period 1996-2000. The EU on the other hand has experienced a much more modest acceleration in labour productivity of a ¼ of a % point over the same period to reach an annual average rate of 2% for the second half of the 1990's.

- The big issue at the present time is whether the higher rates of potential growth estimated to have occurred recently in both the EU and the US merely reflect a procyclical bias in the estimation methods used or do they indicate a trend break in the long run growth performance of both areas which is capable of being sustained over the medium to long run.

5. VINTAGE APPROACH : AN OPERATIONAL ASSESSMENT

- In the production function approach it can be credibly argued, given the uncertainties involved and the range of alternative estimation methods available, that the modelling of TFP is the key methodological issue to be decided upon in calculating potential output growth.
- As explained in the text there are two main alternative methods for calculating trend TFP, namely the vintage approach and the HP filtered Solow Residual approach. In terms of the differences involved, using the "vintage" TFP approach would give a figure of about 2 ¾ % for potential growth in 2000 for the EU15, whereas using a HP filtered Solow Residual to calculate trend TFP would give a figure of roughly 2 ¼ %⁴³. This differential of ½ a % point between the two TFP modelling methods is very large, with the lower estimate supporting the view that no change in potential growth has occurred in the second half of the 1990's in the Community as a whole, whereas if one uses the vintage TFP method then one is implicitly giving the "benefit of the doubt" to the view that the emergence of "new" economy industries in the ICT sector may have resulted in an acceleration in trend growth in the EU over the second half of the 1990's.
- However, a big question to be addressed is whether the more optimistic vintage-generated output estimates for the EU reflect a procyclical estimation bias when using the vintage method. This possible bias emanates from the use of an unsmoothed capital stock series in the PF method which is compounded by the fact that the "vintage" approach is significantly influenced by capital stock developments.
- While it is very difficult to establish the extent to which cyclical factors are playing a role in the vintage method, one possible way to correct for the presence of cyclical influences is to include a variable such as capacity utilisation in the TFP estimation equation. When this was done, however, it was shown that the increase registered in potential output in the EU over recent years is not due to the absence of a capacity utilisation variable, with in the case of the EU15 this variable adding at most 0.1 to the figures in the late 1990's. Given these latter results, one must ask the question whether the capacity utilisation variable is failing to adequately "mop up" the cyclical influences or that the increase in potential growth may not in fact be a procyclical bias and could perhaps be indicating a structural break in the long run growth potential of the EU.
- Only time will tell whether the upturn in EU growth will prove to have been merely a cyclical blip or more permanent in nature. However, despite this uncertainty, following the analysis in sections 3 and 4 of this paper, it is the

⁴³ For the US the vintage approach gives an estimate of 4 ½% compared with 4% using the alternative HP filtered TFP series.

considered view of the authors that for the EU the structural view may be the correct one, with the growth impact of recent increases in investment being bolstered by embodiment effects. In the case of the US, however, the conclusion drawn regarding the sustainability of recent potential growth estimates is very different to that of the EU, with section 4 implicitly suggesting that the 4 ½% potential growth estimate for 2000 for the US may, at least partially, reflect a procyclical estimation bias. In overall terms therefore, applying the "vintage" method, without carefully analysing its underlying driving forces may lead to inappropriate conclusions. Value judgements will always need to be exercised when using this TFP trend extraction approach given the need to carefully interpret any changes in the mean age of the capital stock which are occurring, in terms of both the potential efficiency gains to be reaped and also regarding the nature, and sustainability, of the investment which is taking place.

6. OUTPUT GAP ESTIMATES + POLICY APPLICATIONS

- Over the period 1980-2000 as a whole, for both the US and the EU there are no dramatic differences between the HP and PF approaches in terms of the output gap estimates produced, although differences do clearly emerge in terms of individual year figures.
- As regards the decomposition of output gaps, for the EU, developments in the technology gap and the unemployment gap have tended to offset each other over the last few years, whereas in the US over the same period both the labour market and the production side appear to be operating at above their sustainable rates.
- In addition, in evaluating the usefulness of the different output gap estimates when applied to the two key policy areas to which such "gaps" are generally applied (i.e. inflation and budgetary surveillance), it was found that both the HP filter and PF methods produce broadly comparable results. In relation firstly to inflation surveillance, while output gaps in general would appear to be poor in terms of tracking past movements in price inflation, both of the methods used for calculating the "gaps" are equally poor with regard to their own respective performances. Secondly, in the area of structural budget balances, both methods are broadly symmetric in that any differences sum to zero over the whole cycle and any "biases" at particular stages of the cycle would, using the figures for the EU15 as a whole, be a maximum of 1/2 a percentage point of GDP in any of the years over the period 1980-2000. On the basis of this analysis there would not appear to be a strong **methodological** justification for a switch to using PF generated output gaps as opposed to the present practice in many organisations of using HP filtered generated gaps for inflation and budgetary surveillance purposes.

"NEW" ECONOMY EFFECTS ON POTENTIAL GROWTH

7. RATIONALE FOR INCLUSION OF THE "NEW ECONOMY" SECTION

- The "New Economy" section is included in order to discuss whether the vintage approach is really "optimistic" or whether, in fact, it is more realistic than the HP filter approach given the changes in terms of ICT. According to the "New Economy" material presented, the production function approach may not in fact be optimistic - it may even underpredict potential growth in countries with high

ICT shares in production and investment. Increases in the investment to GDP ratio, as observed in recent years, are having not only a capacity effect but also positive effects on total factor productivity via the embodiment channel.

8. WHAT DOES THIS NEW ECONOMY SECTION CONCLUDE IN TERMS OF THE EFFECTS ON EU AND US POTENTIAL GROWTH

- While the total effect on potential growth is difficult to decipher, from the static and dynamic analysis undertaken in Section 3, it is possible to roughly say that "new" economy factors would appear to have boosted the EU's potential growth rate by about a 1/4 of a percentage point over the second half of the 1990's compared with an acceleration of 3/4 of a % point in the US. It is important to stress that this area-wide increase should not be applied equally to all the constituent Member States. As the analysis in Section 3.1 made clear the evidence so far for "new economy" influences on potential growth is mainly restricted to some of the smaller Member States and perhaps the UK⁴⁴.
- In terms of extrapolating forward the future impact on growth from the ICT, and similar "new" economy, sectors over the coming years, it should be underlined that the signs for the EU economy are still somewhat unclear from the growth experience of the last five years. However, despite these latter uncertainties, if an optimistic view regarding TFP growth is assumed (i.e. that the acceleration in TFP experienced in the ICT sector in the second half of the 1990's persists over the coming decades), then the long run rate of growth could be boosted by 1% point in the US and about half that in the EU15 and persist at that higher rate of growth over the coming decades.

9. STRUCTURAL DIFFERENCES BETWEEN EUROPE AND THE US : HOW IMPORTANT ARE CAPITAL ADJUSTMENT AND LABOUR MARKET RIGIDITIES IN EXPLAINING THE GROWTH DIFFERENTIALS BETWEEN THE EU AND THE US EXPERIENCED OVER RECENT YEARS?

- Section 3 goes on to attempt to answer the important policy question of whether Europe could have benefited substantially more from the ICT revolution if it had a more flexible economy in the form of lower capital adjustment costs and less relative wage rigidities. From the simulations undertaken it would appear that, although both capital adjustment costs and wage rigidities lead to welfare losses in Europe, in terms of growth and employment, they cannot explain the growth differential with the US over the last five years. The best explanation would therefore appear to be differences in the rate of technical progress in ICT production.
- Capital adjustment costs can take various forms, such as, for example, government regulations and organisational adjustment and learning frictions within firms. The observed investment volatility in the US and Europe is consistent with the view that adjustment costs for capital are smaller in the US (i.e. roughly 50% of those in the EU). Reducing adjustment costs for capital in the EU could therefore lead to substantial long term gains, with the increase in the long run growth rate induced by the TFP shock being up to 0.3% points higher than it would otherwise have been. However, in the short run, growth differentials would actually be small and hardly visible in the first 5 years. Consequently, at least within the

⁴⁴ While section 3 does point to some evidence of "new" economy effects in the UK, unfortunately the economy-wide TFP figures shown in Annex 4 do not support this view. Further work is clearly needed to provide a credible explanation for this inconsistency.

technological constraints inherent in standard growth models, higher capital adjustment costs in Europe cannot explain the, ICT induced, US-EU potential growth differential in 2000, without allowing for substantially higher rates of technical progress.

- Regarding labour market flexibility, there are at least two dimensions in which EU labour markets differ from those in the US. Firstly, there are differences in hiring and firing costs. Secondly, there is relatively little wage flexibility across skill groups in EU countries compared to the US and it is the growth implications of the latter which is focussed on in the labour market simulations in this paper. The most striking implication of more wage flexibility in Europe would be an increase in low skilled employment, however at the cost of rising wage dispersion. On the other hand, increasing wage flexibility in Europe would not lead to a substantial increase in the growth rate of GDP. It is interesting to note that the increase in the investment to GDP ratio would actually be smaller; thus labour market reforms would actually slow down the productivity increase and would make growth more labour intensive. This result is not inconsistent with the historically high growth rate of capital intensity in Europe, compared to the US. Therefore, somewhat paradoxically, labour market rigidities actually encourage firms to invest in new, labour-saving, technologies which boost productivity but substitute for low-skilled workers.
- Consequently, rather than blaming "Eurosclerosis" in general for the reason for Europe lagging behind US rates of growth, European policy makers should perhaps instead focus more narrowly on the determinants of the US' apparent comparative advantage in the production of "leading edge", high technology, goods. While large purchases of ICT goods for investment purposes has clearly boosted US growth over the second half of the 1990's, and may in fact through embodiment effects underpin future TFP increases, the simulations suggest that it is more the exceptionally high rates of productivity advances in the production of these goods, rather than the associated capital accumulation effects, which has provided the single greatest contribution to the acceleration in the US's growth performance over the recent past. Furthermore, the TFP acceleration also underpins the belief that the increase in the US' potential growth rate can persist in the long run if one remains optimistic about the pace of future technological change. If past experience is anything to go by, the US has the capacity to retain its comparative advantage in the production of "frontier" technologies.

EU15 AND US POTENTIAL GROWTH SCENARIOS FOR THE PERIOD 2001-2010
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10. PURPOSE OF SCENARIOS

- The essential purpose of the last section of the paper is to verify, through the use of a range of growth scenarios, whether by taking the latest population of working age projections for both the EU and the US and by making various assumptions concerning participation rates, structural unemployment, the investment to GDP ratio and other TFP trends, it is credible to predict that the most recent production function generated potential output estimates for the EU and the US will be sustained over the next 10 years.

11. BROAD DETERMINING FEATURES OF THE PESSIMISTIC, CENTRAL AND OPTIMISTIC SCENARIOS

- **PESSIMISTIC SCENARIO** : This scenario is underpinned by the view that both the slight upturn in potential growth in the EU witnessed over the period 1996-2000 and the much stronger US performance over the same period were essentially only cyclical in origin and consequently the trend TFP growth rates witnessed in the first half of the decade, and indeed over the 1980's as well, will re-establish themselves in both areas over the coming decade. This scenario can be seen as a negation of the "new" economy story, suggesting as it does that the long run patterns established over the 1980-1995 period have not been permanently altered by the developments of the last number of years.
- **CENTRAL SCENARIO** : The central scenario gives the "benefit of the doubt" to "new" economy advocates, with the trends established over the second half of the 1990's being used as the basic framework for the assessment for 2001-2010 for both areas. For the EU, in addition to the assumption that the modest, but accelerating, "new" economy effects evident over the late 1990's will persist over the forecast horizon, ongoing labour market reforms are also assumed. The latter reform efforts should result in sizeable labour potential effects both in the form of downward movements in the NAIRU and an ongoing increase in participation rates.
- **OPTIMISTIC SCENARIO** : This final set of simulations can be seen as providing a strong endorsement for the growth impact of the "new" economy in both the US and the EU. For the EU, the optimistic variant could also be described as a type of "Lisbon Scenario" with Europe taking the necessary structural measures needed to start on the road to becoming "the most competitive and dynamic, knowledge-based, economy in the world".

12. CENTRAL EU SCENARIO

- In the case of the EU, on the basis of the analysis undertaken in section 4, the production function generated 2 ¾ % potential growth rate indicated for 2000 for the EU does indeed seem justifiable as an indication of sustainable output growth in the Community over the medium to long run. This rate of growth in fact constitutes the central scenario assumed for the EU over the next 10 years and is dependent, for its realisation, on movement along a policy path which is broadly consistent with the Lisbon strategy.

13. CENTRAL US SCENARIO

- In the case of the US, however, the production function estimated potential output figure of 4½ % indicated for 2000 is not, according to section 4, sustainable, not because of a fundamental rethink in terms of the "new" economy effects but more because of the associated investment implications. The central scenario assumes that the investment to GDP ratio in the US will fall back to around 20%, a rate still some 3 ½ percentage points above that of the early 1990's and that of the 1980's. In these circumstances, the central estimate for the long run rate of growth in the US for the next 10 years is 3%, which is substantially below the "technical capacity" indication of 4 ½% for 2000.
- The example of the US is important in highlighting the need to carefully scrutinize the underlying determinants of growth as opposed to the unquestioning acceptance of model based estimates. The production function / growth accounting

framework is a useful analysis tool but one which must be accompanied by a considered evaluation of all the pertinent contributory factors.

CONCLUDING REMARKS

METHODOLOGICAL ISSUES: This paper has presented an overview of the various methodologies for estimating potential output at the macroeconomic level. Emphasis was laid on the production function approach which is used together with the univariate statistical HP filter method. Both methods can be regarded as extremes concerning the use they make of economic information although both yield broadly similar results concerning the cyclical nature of trend/potential output. Concerning the current economic situation, potential growth estimates based on a production function approach tend to be more optimistic than trend estimates based on the HP filter. This is not surprising given the stress placed on investment in the production function method, emphasising both its capacity and embodiment effects.

"NEW" ECONOMY AND EU-US GROWTH DIFFERENTIALS : On the basis of the technology assumptions adopted in this study, the EU-US growth differential would persist over the coming decades (or on the basis of the optimistic scenario the growth performance would be equal) unless Europe can start to bridge the "technology gap" by boosting its TFP performance to rates of growth in excess of those predicted for the US. An overall growth performance equivalent to or exceeding that of the US will only, of course, be achievable here in Europe if countries prove capable of introducing the necessary policy changes required to achieve a rapid shift in both investment and production towards those fast growing ICT, and indeed other emerging "new" economy, sectors (in terms of TFP), which have been a hallmark of the US' stellar growth performance over the recent past and which look likely to continue to underpin its future dynamism. Unless the requisite changes are introduced, previous EU episodes of rapid catching up with the US, in terms of overall growth and productivity differentials, may in future prove to be a more drawn out process. As stated earlier, EU governments must not use the well rehearsed "Eurosclerosis" arguments as an excuse for inaction but should instead focus on those aspects of the US business environment which appear to give the US an advantage in the production of high-technology goods.

NATURE OF PRODUCTIVITY SHOCK : In this concluding section, it is important to reiterate again the specific nature of the TFP shock which has, and is, occurring in the US and which is starting to manifest itself, but to a lesser extent, in Europe. The 1% point boost to TFP growth in the US predicted in the optimistic scenario in section 4 emanates from massive, and well documented, productivity gains in that country's ICT producing sector, with these efficiency gains leading to price declines for ICT investment goods and to a consequent upsurge in demand for these latter goods from all sectors of the economy. While one can be reasonably confident in asserting that the ICT sector will continue to experience further TFP improvements over the next 10 years, the real question mark hanging over the "new economy" thesis is whether the large investment in ICT products which has already taken place will produce the efficiency gains which are necessary for a sector-specific productivity boost, such as that in ICT, which is not unusual in historical terms in the normal cycle of expanding

and contracting sectors, to become a pervasive "economy-wide" upturn in trend productivity.

In the case of the US, if the "spillover" effects from the ICT to the non-ICT parts of the economy are not forthcoming, as people like Gordon and Triplett suggest, then investment levels could return to their, long run, lower, trend rates very quickly indeed as companies re-assess the likely gains from such investments and, in the short run, address more pressing balance sheet-related concerns. This view is supported by recent developments in the US which has already undermined some central tenets of the "new" economy paradigm, such as, for example, the rather far-fetched suggestion of its immunity from normal business cycle fluctuations. Consequently, we may be entering a more "sober" phase in terms of an assessment of the likely gains from technological progress in the ICT sector. Earlier assertions that there would be significant spillover effects, equivalent to previous technological revolutions, for example those associated with electricity production and the many industries which the latter spawned, appear at this stage to be exaggerated. The productivity gains in the non-ICT sectors have yet to be confirmed and the success of the new industries which have emerged, such as E-commerce operations and a wide array of ICT-based service and product providers, would give grounds for considerable caution.

However, while the "froth" of euphoria surrounding the ICT sector may have begun to dissipate, it is still fair to state that the underlying ICT thesis still holds: namely, that ICT productivity gains have led, and should continue over the next 10 years to lead, to lower investment goods prices and consequently to a lower cost of capital and an associated increased incentive to invest on behalf of economic agents. When all the hype surrounding the ICT revolution has long gone, it will be this underlying feature which will sustain the view that this "revolution" has indeed led to long run growth gains but those gains are likely to be at the lower end of what many commentators had earlier expected.

FUTURE RESEARCH AGENDA : While a lot of work has already been done in this area it is clear that this is an ongoing research topic, with future research likely to be concentrated on the following themes :

- ongoing experimentation with new methodologies, most notably Kalman Filters (where work has already commenced in terms of their use in NAIRU calculations);
- examining the possibility of a further decomposition of the "production" component of the output gap into technology shocks and fluctuations in capacity utilisation;
- looking again at the issue of the procyclicality of the "vintage" TFP method, by experimenting with alternative capacity utilisation indicators or by using model simulations to estimate the size of any pro-cyclical estimation bias which may exist;
- and finally, extending and deepening the analysis of "new" economy influences on potential growth developments.

DIAGRAM 11 : KEY CONCLUSIONS ON POTENTIAL GROWTH

1 : STATISTICAL (HP-FILTER) + ECONOMIC (PRODUCTION FUNCTION) MEASUREMENT METHODS COMPLEMENT EACH OTHER

2 : POTENTIAL OUTPUT ESTIMATES

EU15		
1991-1995 2.1 %	1996-2000 2.4 %	2000 2.8% (1998-2002 2.7%)

US		
1991-1995 2.6 %	1996-2000 3.9 %	2000 4.6% (1998-2002 4.4%)

3 : NEW ECONOMY INFLUENCES ON GROWTH

EU15

PAST GROWTH
= + $\frac{1}{4}$ %
FUTURE GROWTH
= + $\frac{1}{2}$ %

US

PAST GROWTH
= + $\frac{3}{4}$ %
FUTURE GROWTH
= + 1 %

4 : POTENTIAL GROWTH SCENARIOS 2001-2010

EU15		
PESSIMISTIC 1 $\frac{3}{4}$ %	CENTRAL 2 $\frac{3}{4}$ %	OPTIMISTIC 3 $\frac{1}{2}$ %

US		
PESSIMISTIC 2 %	CENTRAL 3 %	OPTIMISTIC 3 $\frac{1}{2}$ %

REFERENCES

AGHION, P. AND P. HOWITT (1998), "Endogenous Growth Theory", the MIT Press, Cambridge, Mass.

BARRO, R. AND X. SALA-I-MARTIN (1995), "Economic Growth", McGraw-Hill.

BASSANINI, A., SCARPETTA, S. AND I. VISCO. (2000), "Knowledge, Technology and Economic growth: Recent Evidence from OECD Countries", OECD Working Paper No. 259.

BANCA D'ITALIA (1999), "Indicators of Structural Budget Balances", Research Department, Public Finance Workshop.

BAXTER M. AND R.G. KING (1995), "Measuring business cycles: approximate band-pass filters for economic time series", NBER Working Paper, No. 5022.

BEVERIDGE S. AND C.R. NELSON (1981), "A new approach to the decomposition of economic time series into permanent and transient components with particular attention to measurement of the business cycle", Journal of Monetary Economics, Vol. 7.

BLANCHARD O.J. (1990), "Suggestions for a new set of fiscal indicators", OECD Working Paper, No. 79.

BLANCHARD O.J. AND D. QUAH (1989), "The dynamic effect of aggregate demand and supply disturbances", American Economic Review, No. 79.

BURNSIDE, C., EICHENBAUM, M. AND S. REBELO (1995), "Capital Utilisation and Returns to Scale", in NBER Macroeconomics Annual 1995, Edited by B. Bernanke and J. Rotemberg, MIT Press, pp 67-109.

CANOVA F. (1999), "Does detrending matter for the determination of the reference cycle and the selection of turning points?", The Economic Journal, No. 109.

CECCHETTI, S. (2000), "Early warning signs of the U.S. productivity pickup: Implications for Europe", Mimeo, Ohio State University, August 2000.

CERRA, V. AND S.C. SAXENA (2000), "Alternative Methods of Estimating Potential Output and the Output Gap: An Application to Sweden", IMF Working Paper.

CLAUS, I. (2000), "Is the output gap a useful indicator of inflation", Reserve Bank of New Zealand, Discussion Paper Series.

DAVERI, F. (2000), "Is growth an information technology story in Europe too? *IGIER Working Paper*, September.

DE MASI, P (1997), "IMF Estimates of Potential Output: Theory and Practice", Staff Studies for the World Economic Outlook, December.

DOMAR, E. (1961), "On the measurement of technological change" Economic Journal, Vol. 71, No.284.

EASTERLY, W. AND R. LEVINE (2000), "It's not factor accumulation: Stylized facts and growth models", World Bank, University of Minnesota, Mimeo.

EUROPEAN COMMISSION (1995), "Technical note: The Commission services' method for the cyclical adjustment of government budget balances", European Economy, No.60, November.

EUROPEAN COMMISSION (2000), "The EU Economy - 2000 Review"

EUROSTAT (1999), "Volume measures for computers and software", Report of the Task Force, Luxembourg.

FORNI M. AND L. REICHLIN (1998), "Cyclical adjustment of government budget balances: evaluation of alternative trend estimation methods and of the cyclical sensitivity of budgetary components", Internal Study for the DG ECFIN, July.

GIORNO C., RICHARDSON P., ROSEVEARE D. AND P. VAN DEN NOORD (1995), "Estimating potential output, output gaps and structural budget balances", OECD Working Paper, No. 152.

GIORNO C., RICHARDSON P. AND W. SUYKER (1995), "Technical Progress, Factor Productivity and Macroeconomic Performance in the Medium Term", OECD Working Paper, No. 157.

GORDON, R. J. (1997), "The Time-Varying NAIRU and its Implications for Economic Policy", Journal of Economic Perspectives (Winter).

GORDON, R. J. (1999), "Has the New Economy rendered the productivity slowdown obsolete?", mimeo, Northwestern University, April 1999.

GORDON, R. J. (2000), "Does the 'new economy' measure up to great inventions of the past?", NBER working paper, No 7873.

GRILICHES, Z. (1994), "Productivity, R&D and the Data Constraint", American Economic Review, Vol. 84.

GRILICHES, Z. (1997), "Education, human capital and growth: a personal perspective", Journal of Labour Economics, Vol.15.

HAMILTON, J. D. AND J. MONTEAGUDO (1998), "The augmented Solow model and the productivity slowdown", Journal of Monetary Economics, Vol. 42, pp. 495-509.

HARVEY, A. C. (1989), "Forecasting, Structural Time Series Models and the Kalman Filter." Cambridge University Press, Cambridge.

HARVEY, A. C. AND A. JAEGER (1993), "Detrending, Stylized Facts and the Business Cycle." Journal of Applied Econometrics 8, pp. 231-47.

HODRICK R.J. AND E.C. PRESCOTT (1980), "Post-war U.S. business cycles: an empirical investigation", Carnegie-Mellon University discussion paper, No 451.

HULTEN, C. (2000). "Total Factor Productivity :A Short Biography", NBER Working Paper, No. 7471.

IMF (1993). "Structural Budget Indicators for the major industrial countries", World Economic Outlook, October.

JORGENSEN, D.W. AND K. STIROH (1995). "Computers and growth", Economics of Innovation and New Technology, Vol. 3, No 3-4, pp. 295-316.

JORGENSEN, D.W. AND K. STIROH (2000a). "Raising the Speed Limit: U.S. economic growth in the Information Age", Brooking Papers on Economic Activity, pp. 125-235.

JORGENSEN, D.W. AND K. STIROH (2000b). "U.S. economic growth at the industry level", American Economic Review, Vol. 90, No 2.

KING R.G. AND S.T. REBELO (1993). "Low frequency filtering and real business cycles", Journal of Economic Dynamics and Control.

KYDLAND F.E. AND E.C. PRESCOTT (1989). "A Fortran subroutine for efficiently computing Hodrick-Prescott-filtered time series", Federal Reserve Bank of Minneapolis, research memorandum.

KRUSELL, P., OHANIAN, L.E, RIOS-BULL, J-V. AND G. VIOLANTE (2000). 'Capital skill complementarity and inequality: A macroeconomic analysis', Econometrica, Vol. 68, No.5.

KUTTNER, K. N. (1994). "Estimating Potential Output as a Latent Variable." Journal of Business & Economic Statistics 12, pp. 361-68.

MANKIW, N. G., ROMER, D. AND D. N. WEIL (1992). "A contribution to the empirics of economic growth", Quarterly Journal of Economics, Vol. 107, pp. 407-437.

MARAVALL, A. (1996). "Unobserved Components in Economic Time Series." Banca de Espana, Working Paper No. 9609.

MC MORROW, K. AND W. ROEGER (2000). "Time-Varying NAIRU / NAWRU Estimates for the EU's Member States " ECFIN Economic Paper No. 145.

NELSON, C. AND C.I. PLOSSER (1982). "Trends and random walks in macroeconomic series", Journal of Monetary Economics, No.10.

NORDHAUS, W. (2001). "Alternative Methods for measuring productivity growth", NBER Working Paper No. 8095.

NORDHAUS, W. (2001). "Productivity Growth and the New Economy", NBER Working Paper No. 8096.

OECD (2000). "A new economy ? The role of innovation and information technology in recent OECD economic growth", OECD, Paris.

OLINER, S.D. AND D.E. SICHEL (1994), "Computers and output growth revisited: how big is the puzzle?", Brookings Papers on Economic Activity, Vol. 2, pp. 273-317.

OLINER, S.D. AND D.E. SICHEL (2000), "The resurgence of growth in the late 1990's: is information technology the story?", US Federal Reserve Board.

ONGENA H. AND W. RÖGER (1997), "Les estimations de l'écart de production de la Commission européenne", *Economie Internationale*, No. 69.

ORLANDI, F. AND W. RÖGER (1999), "The unobserved Components Method for Calculating Output Gaps", Technical Note for the EPC Working Group on Output Gaps, DG ECFIN, mimeo.

ORLANDI, F. AND K. PICHELMANN (2000), "Disentangling Trend and Cycle in the EUR11 Unemployment Series - An unobserved Component Modelling Approach", ECFIN Economic Paper No. 140.

PERRON P. (1989), "The big crash, the oil shock and the unit root hypothesis", *Econometrica*.

PERRON P. (1997), "Further Evidence on breaking trend functions in macroeconomic variables", *Journal of Econometrics*, No. 80.

PRESCOTT E.C. (1986), "Theory ahead of Business-Cycle measurement", Carnegie-Rochester Conference on Public Policy, No. 25.

RÖGER W. (1994), "Total Factor Productivity in West German Manufacturing: Is there Investment Induced Technical Progress?", *Allgemeines Statistisches Archiv*, 78, pp. 251-61.

RÖGER, W (2001), "The Contribution of Information and Communication Technologies to Growth in Europe and the US: A Macroeconomic Analysis", DG ECFIN Economic Papers, No 147.

RÖGER W. AND J. IN 'T VELD (1997), "Quest II - A multi country business cycle and growth model", DG ECFIN, Economic Papers, No 123.

ROMER, P. (1986), "Increasing returns and long-run growth", *Journal of Political Economy*, Vol. 94, pp. 1002-1037.

SCHREYER, P. (2000), "The contribution of information and communication technology to output growth. A study on the G7 countries", OECD STI Working Papers No. 2000/2.

SCOTT, A. (2000), "Stylised facts from output gap measures", Reserve Bank of New Zealand, Discussion Paper Series.

SOLOW, R. (1956), "A contribution to the theory of economic growth", *Quarterly Journal of Economics*, Vol. 70, No 1, pp. 65-94.

STIROH, K. (1999), "Is there a new economy?", *Challenge*, July/August, pp. 82-101.

STIROH, K. (2000), "What drives productivity growth?", Mimeo, Federal Reserve Bank of New York, July 2000.

TEMPLE, J. (2000), "Summary of an Informal Workshop on the Causes of Economic Growth", OECD Working Paper, No. 260.

TRIPLETT, J. E. (1999), "Economic statistics, the new economy and the productivity slowdown" forthcoming in Business Economics.

TURNER, D., RICHARDSON, P. AND S. RAUFFET (1996), "Modelling the Supply side of the seven major OECD economies", OECD Working Paper, No. 167.

UK TREASURY (1996), "How fast can the economy grow ? A special report on the output gap", Panel of Independent Forecasters, June.

VAN ARK, B. (2000), "Measuring Productivity in the "New Economy: Towards a European Perspective", De Economist, No 1.

VAN DER WIEL, H. (2000), "Is ICT important for growth", CPB report, No 2.

WEISS, A (1995), "Human Capital vs. Signalling Explanations of Wages", Journal of Economic Perspectives, Vol. 9, No 4.

WHELAN, KARL (2000), "Computers, Obsolescence, and Productivity", Federal Reserve Board Finance and Economics Discussion Paper, No. 2000-6.

WOLFF E.N. (1996), "The Productivity Slowdown: The Culprit at Last?", American Economic Review, 86, pp. 1239-55

LIST OF ANNEXES

- ANNEX 1 :** DETAILED ASSESSMENT OF THE HP FILTER METHOD
- ANNEX 2 :** CALCULATION OF THE MEAN AGE OF THE CAPITAL STOCK
- ANNEX 3 :** LEVELS V GROWTH RATES IN POTENTIAL OUTPUT ANALYSIS
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ANNEX I. : THE HODRICK-PRESCOTT FILTER

Using a Hodrick-Prescott filter to detrend GDP is effectively equivalent to applying a moving average filter. Weights are symmetric around -and higher the closer to- the reference year. This implies a smooth trend, without phase shifts (i.e. no leads or lags in turning points in the cycle) where output gaps are symmetric, i.e. output gaps sum by construction to zero over the cycle. As such, the estimated trend GDP is merely a measure of the average GDP level, without any ambition towards having a normative content.

The Hodrick-Prescott filter is obtained by minimising fluctuations in actual output around trend output subject to a constraint on the variation of the growth rate of trend output. The setting of the smoothing parameter λ in the minimisation problem is arbitrary. A λ at 0 implies that trend and actual output coincide, while a $\lambda \rightarrow \infty$ implies a linear trend. In terms of output gaps, a smaller λ implies shorter cycles and smaller gaps. Following what has become the norm in the literature and among practitioners, this paper sets λ at 100. In terms of the length of business cycles affecting the cyclical component, a λ at 100 means that cycles shorter than 15-16 years are retained while cycles above 20 years are fully filtered out.

There is also the “end point bias” problem, which relates to the fact that the otherwise symmetric Hodrick-Prescott filter becomes asymmetric towards the end of the series, with a disproportionate emphasis placed on the last few observations. “End point effects” are mainly noticeable for the last 3-4 observations in the series. One way of restoring symmetry is to extend the data series that is being analysed with projections, a line followed by the present paper. This solution has nevertheless the disadvantage of adding a forecast error problem. However, sensitivity calculations show that this seems to be limited in size and should not have a major qualitative impact. The text below looks more deeply at the HP filter in the context of its use by the Commission services in its cyclical adjustment method for calculating structural budget balances.

1. MAIN CHARACTERISTICS

To obtain estimates for trend output, the Commission services’ cyclical adjustment method applies the Hodrick-Prescott filter to the actual output series. The Hodrick-Prescott filter is obtained by minimising the regular fluctuations in actual output around trend output subject to a constraint on the variation of the growth rate of trend output.

Box:

Technical specification of the Hodrick-Prescott filter

$$\text{Min} \sum_{t=1}^T (\ln Y_t - \ln Y_t^*)^2$$

subject to

$$\sum_{t=2}^{T-1} \left[(\ln Y_{t+1}^* - \ln Y_t^*) - (\ln Y_t^* - \ln Y_{t-1}^*) \right]^2 \leq e$$

where: Y_t = actual GDP at constant market prices
 Y_t^* = trend GDP at constant market prices
 e = small number arbitrarily chosen

The problem can be re-written as follows:

$$\text{Min} \sum_{t=1}^T (\ln Y_t - \ln Y_t^*)^2 + \lambda \sum_{t=2}^{T-1} \left[(\ln Y_{t+1}^* - \ln Y_t^*) - (\ln Y_t^* - \ln Y_{t-1}^*) \right]^2$$

where: λ = Lagrange multiplier

The technical specification of the Hodrick-Prescott filter imposes a trade-off between the smoothness and fit to actual output of trend output: the smoother trend output, the poorer its fit to actual output and vice versa. This trade-off is determined by the choice of the value for the Lagrange multiplier λ . The value of the Lagrange multiplier λ also determines the smoothness of the trend estimates. A low value of λ produces trend output estimates which closely follow actual output and are therefore very volatile, while a high value of λ produces very smooth trend estimates which follow actual output less closely. For values of λ which tend to infinity, the growth rates of trend output would remain constant and would therefore correspond to the results obtained with the split time-trend estimation method.

It has been shown by King and Rebelo (1993), that applying the HP filter results effectively in a moving average filter. The output gap can be regarded as generated by the following moving average filter:

$$GAP_t = HP(L)y_t$$

where $HP(L)$ is a lag polynomial $HP(L) = \sum_{j=-\infty}^{\infty} b_j L^j$ in the lag operator L and the filter weights b_j have the following properties:

Symmetry: $b_j = b_{-j}$

Weights sum to zero: $\sum_{j=-\infty}^{\infty} b_j = 0$.

The weighting coefficients of the moving averages are fixed in such a way that higher weights are assigned to the years closest to the reference year, i.e. the year for which trend output is calculated. The filter weights are symmetric, i.e. observations in a similar position on each side of the central observation are given equal weights.

It has been shown by Baxter and King (1995) that moving average filters whose weights sum to zero have a trend reduction property, i.e. they make time series stationary which have linear and quadratic deterministic trends and they also render series with stochastic trends up to order 2 stationary⁴⁵. Symmetry is also a desirable property since it implies that no phase shift - i.e. a movement in time of the turning points of the series - is introduced.

2. CHOICE OF THE SMOOTHING PARAMETER λ

Any degree of smoothness can be achieved with the Hodrick-Prescott filter by setting specific values of the smoothing parameter λ . In order to gain a better insight into the question of which cyclical components of GDP are actually extracted by this filter for specific values of the smoothing parameter, it is useful to use frequency domain methods.

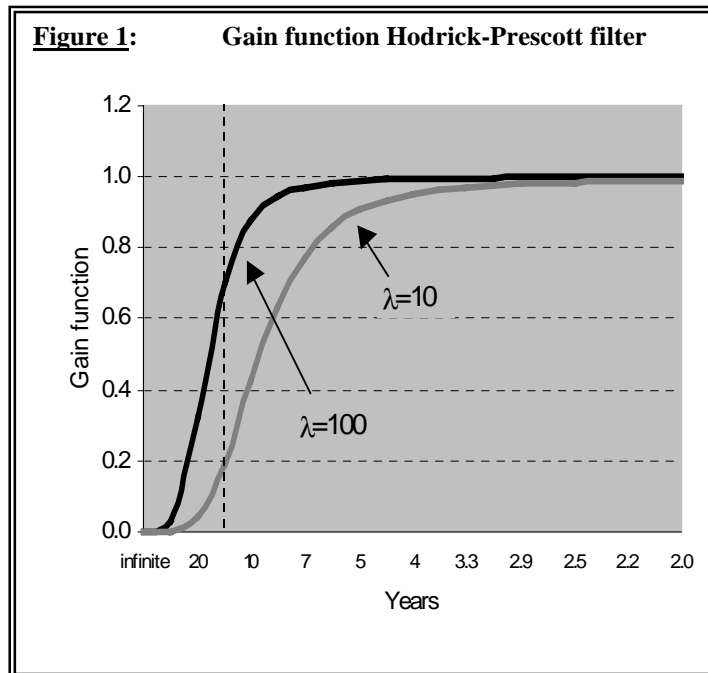
This framework can be used to analyse which cyclical frequencies are suppressed by the Hodrick-Prescott filter. Which cyclical components are dampened and which

⁴⁵ The level of a process with a stochastic trend of order one contains a random walk component. The growth rate of a process with a stochastic trend of order two contains a random walk component. Most macroeconomic time series can be regarded as integrated of order one; this holds in particular for real GDP. The price level is an example of a process which is integrated of order 2, since the inflation rate often exhibits random walk properties.

components are kept is expressed by the gain function $C^F(\theta)$ which attaches a weight to each component with frequency θ or correspondingly cycle length $2\pi/\theta$.

The Hodrick-Prescott filter eliminates cycles with infinite duration or trends while it passes cycles with higher frequencies. The smoothing parameter λ determines to what extent low frequency cycles are eliminated from the data. When using the Hodrick-Prescott filter in the cyclical adjustment method, the Commission services set λ equal to 100, which corresponds to standard practice.

Figure 1 plots C^F for two alternative values of λ . It can be seen that for $\lambda = 100$ the Hodrick-Prescott filter hardly dampens cyclical components up to a period of 15 to 16 years, while it practically eliminates all cycles with a period larger than 20 years. In contrast, for $\lambda = 10$ only cycles up to 8 years would be retained fully in the cyclical component. Baxter and King (1995), for example, have suggested to set the smoothing parameter λ equal to 10. In light of what is generally regarded as a typical business cycle length, the Commission services' choice (and the option chosen in this paper) may seem a rather generous definition of the cycle.



In earlier work output gaps were constructed with alternative values for the smoothing parameter λ for all EU Member States. It was seen that with $\lambda = 10$, that the output gaps tended to be smaller both in terms of the amplitude as well as the cycle length.

3. END POINT BIAS PROBLEM

With actual data and finite samples, a problem arises with symmetric filters, because the theoretically infinite moving average must be truncated at a finite lag or the filter must be constructed in such a way that the filter weights become asymmetric at the end points.

Baxter and King (1995) show that, close to the end points - especially the last 3 to 4 observations -, the Hodrick-Prescott filter not only eliminates the low frequency cycles it is supposed to eliminate, i.e. cycles with a cycle length of more than 16 years, but also has a tendency to dampen the influence of cycles with higher frequencies. This will affect cyclical components with a period larger than 4 years. Only cycles with shorter periods will be fully passed. This implies that the Hodrick-Prescott filter produces a series for the output gap which underestimates the length of the cycle close to the end point, if no corrective measures are taken.

Since this phenomenon especially occurs for the last 3 or 4 observations, one possibility to correct for this bias is to extend the data set by adding GDP forecasts over a range of 3 to 5 years. This is standard practice which is also the approach followed by the Commission services.

Mechanical projections - obtained with ARIMA-models⁴⁶ - are added by the Commission services to extend the actual output series on which the Hodrick-Prescott filter is then applied. The approach chosen for generating these projections is in keeping with that followed by the Commission services for the cyclical adjustment method. The projections are calculated mechanically and can be easily reproduced. The aim is to add observations which are characteristic for the actual output series, i.e. which show average growth rates, to counterbalance observations which are uncharacteristic for the rest of the series.

Of course, the addition of forecasts to prolong the series is only a second-best solution for the end point bias problem: this problem only disappears once all observations influencing the calculation of the trend estimate have become available as historical data. By adding forecasts to the data series, a forecast error problem is added and it has to be checked how severe this problem may be. Since the Hodrick-Prescott filter uses leads for calculating the trend component, the forecasted values of GDP will obviously influence the trend and consequently the output gap estimate to some extent.

It is possible to assess the significance of this end point problem of the Hodrick-Prescott filter by comparing the Commission's estimate of the output gap for all EU Member States with an output gap constructed on the basis of the standard Hodrick-Prescott method without extending the output series with forecasts. Two observations can be made on the basis of this exercise :

- not extending the series clearly dampens the period of the last cycle;
- noticeable deviations between the two output gaps occur about 3 to 4 years before the final observation, which confirms the findings of Baxter and King.

In order to analyse how sensitive the output gap estimates are to changes in the forecast, output gaps calculated by the Commission services have been compared with two alternatives. Under the first alternative, it is assumed that GDP growth exceeds the mechanical projection by 0.5 percentage points each year over the period 2001 to 2004 while under the second alternative it is assumed that the ARIMA-forecast is too optimistic and over-predicts growth by 0.5 points in each year after 2000. The results indicate that a change in the forecast of 0.5 percentage points translates into a change in the output gap of close to 0.1 percentage points of trend GDP in, for example, 1998 and 0.2 percentage points in 1999. This sensitivity is strikingly similar across all countries and does not seem to be related strongly to the cyclical position.

⁴⁶ To calculate the output gaps used in the cyclical adjustment method, the Commission services add two years of forecasts made by the country desks and published officially as the Commission forecasts. This series is then extended with 4 years of mechanical projections obtained via "Auto-Regressive Integrated Moving Average" (ARIMA, Box Jenkins) specifications of the time series. These models are characterised in the literature as powerful forecasting procedures for the short term for a large number of time series.

4. FREQUENCY REPRESENTATION OF HP FILTER

Economic time series are composed of cyclical functions of time such as:

$$y_t = a \cos(\theta t)$$

Since y goes through a complete cycle as $x = \theta t$ goes from 0 to 2π , the parameter θ (or the frequency) implicitly defines the time it takes for y to complete a full cycle, or in other words the *period* of the cycle. The period (p) is implicitly defined as $p = 2\pi / \theta$. For example, the frequency of a cycle that repeats itself every 8 years would be given by $2\pi / 8$ with annual data. Also notice with annual data that one can only analyse cycles with a period of at least 2 years. That implies the interval of possible frequencies is given by $[0, \pi]$.

This framework can be used to analyse which frequencies are suppressed by certain types of filters and in particular the Hodrick-Prescott filter. King and Rebelo (1993) have shown that the cyclical component of the Hodrick-Prescott filter can be written as follows.

Let the cyclical component of GDP after filtering with the Hodrick-Prescott method be given by:

$$y_t^c = [1 - HP(L)]y_t$$

Define $C(L) = (1 - HP(L))$, then the Fourier transform is given by

$$C^F(\theta) = \frac{2\lambda\sqrt{1 - \cos(\theta)}}{1 + 2\lambda\sqrt{1 - \cos(\theta)}}$$

Since $\cos(\theta) = 1$ for $\theta = 0$ and $\cos(\theta) = -1$ for $\theta = \pi$ it is easy to see that the Hodrick-Prescott filter eliminates cycles with zero and low frequencies while it passes cycles with higher frequencies. It can also be seen from this expression that the smoothing parameter λ determines to what extent low frequency cycles are eliminated from the data.

ANNEX 2 : THE MEAN AGE OF CAPITAL (AGEM)

This annex provides a discussion of the mean age of capital and explains, in particular, how the mean age of capital can be constructed on the basis of information on the real capital stock and the rate of depreciation.

Let I and K be real fixed capital formation and the capital stock respectively. Furthermore, assume geometric depreciation with rate d . Then the capital stock evolves according to

$$(1a) \quad K_t = I_t + (1-d)K_{t-1}$$

Alternatively the capital stock can be expressed as the sum of the surviving or non-depreciated capital invested in the past

$$(1b) \quad K_t = \sum_{i=0}^{\infty} (1-d)^i I_{t-i}$$

Using (1b), the total age of the capital stock can be calculated by multiplying the surviving investment undertaken in period $t-i$ with its age where we adopt the convention that the age of the capital created in the current period is set equal to one. Therefore, the total age of capital (AGEK) is given by

$$(2) \quad AGEK_t = \sum_{i=0}^{\infty} (i+1)(1-d)^i I_{t-i}$$

where $i+1$ denotes the age of vintage i . Using this definition a recursive formula for AGEK can be derived as follows. First, multiply AGEK, lagged one period with $(1-d)$

$$(3) \quad (1-d)AGEK_{t-1} = \sum_{i=0}^{\infty} (i+1)(1-d)^{i+1} I_{t-1-i}$$

Second, take the difference between (2) and (3) and observe that lagged investment in this difference simply adds up to total capital

$$(4) \quad AGEK_t - (1-d)AGEK_{t-1} = IQ_t + (1-d)IQ_{t-1} + \dots = \sum_{i=1}^{\infty} (1-d)^i IQ_{t-i} = K_t$$

Therefore the infinite sum (2) can be written recursively as follows:

$$(5) \quad AGEK_t = (1-d)AGEK_{t-1} + K_t$$

Given this expression and a series for the capital stock, AGEK can be calculated on the basis of an initial value for AGEK. There exist various possibilities to estimate an initial value for AGEK. Here only two possibilities are discussed.

1. USING PRE-SAMPLE INFORMATION/JUDGEMENT FOR K : Let the average pre-sample growth rate of the capital stock be given by g_K , then using (5) one can calculate $AGEK_0$ as

$$AGEK_0 = \frac{K_0}{(1-d-g_K)}$$

There may not however be enough information for following this strategy, therefore an alternative is to estimate AGEK from the in-sample information.

2. USING IN-SAMPLE INFORMATION: Given the specification one is interested in estimating, it is generally possible to reformulate the equation in such a way that the initial age of capital can be estimated as an additional parameter. In the present case, the objective is to estimate the following equation for TFP :

$$TFP_t = \pi T + \beta \frac{AGEK_t}{K_t} + \varepsilon_t$$

Rewrite AGEK explicitly as a function of the initial age as follows

$$AGEK_t = \sum_{j=0}^{t-1} (1-d)^j K_{t-j} + (1-d)^t AGEK_0$$

and define the observable (within sample) expression

$$KS_t = \sum_{j=0}^{t-1} (1-d)^j K_{t-j}$$

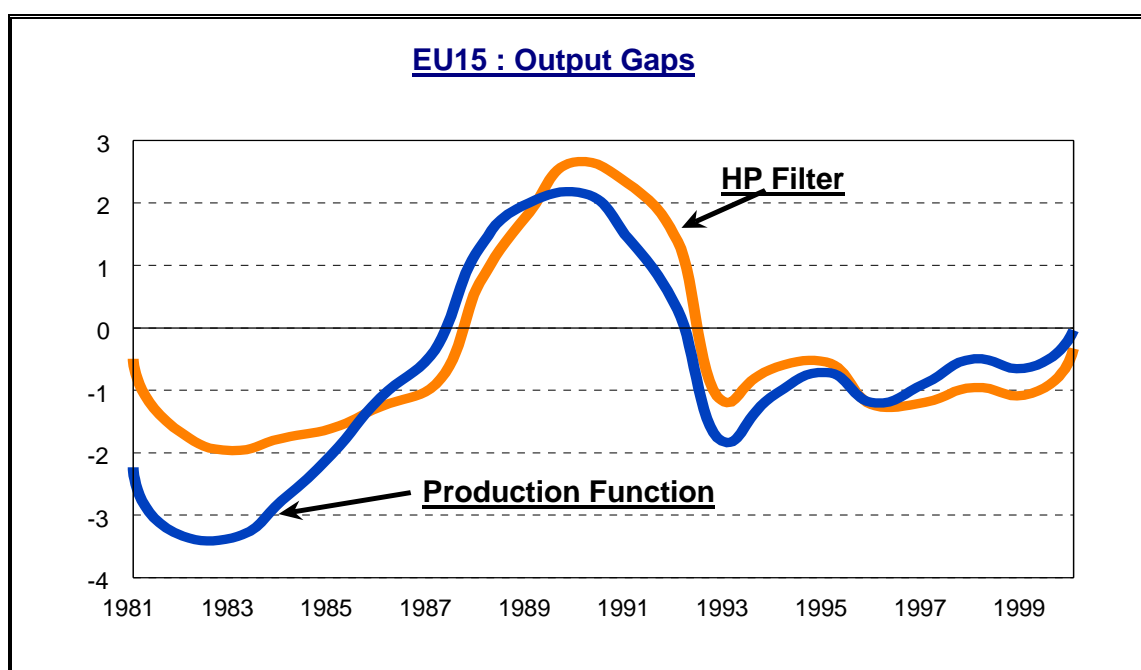
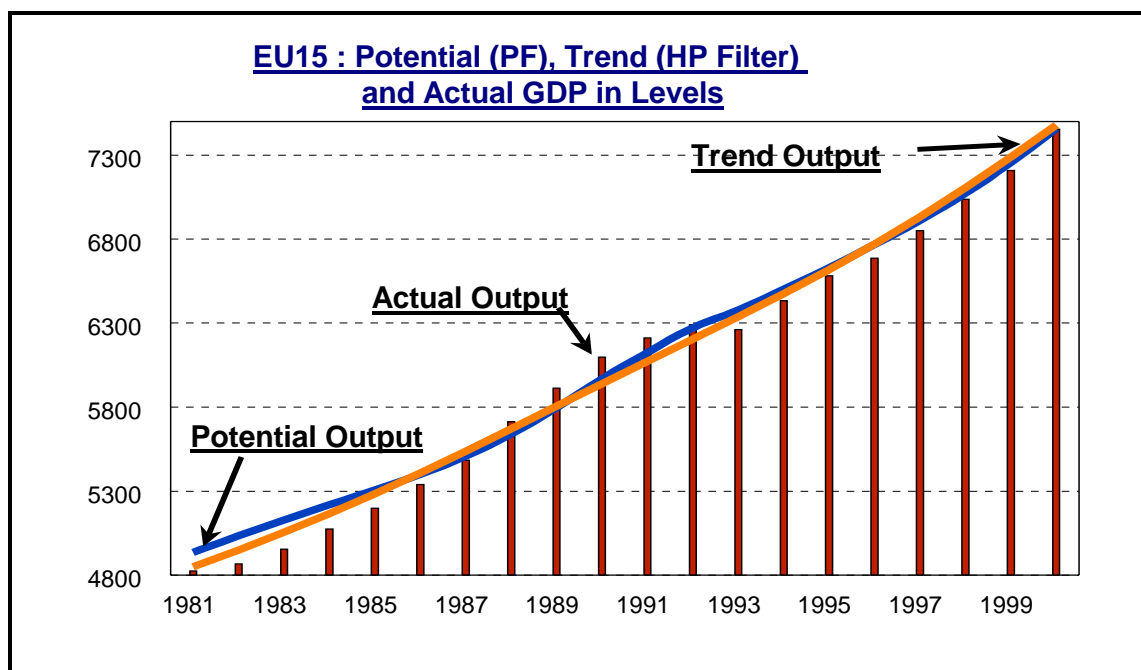
Now one can rewrite the TFP regression as follows

$$TFP_t = \pi T + \beta \frac{KS_t}{K_t} + \beta AGEK_0 \frac{(1-d)^t}{K_t} + \varepsilon_t$$

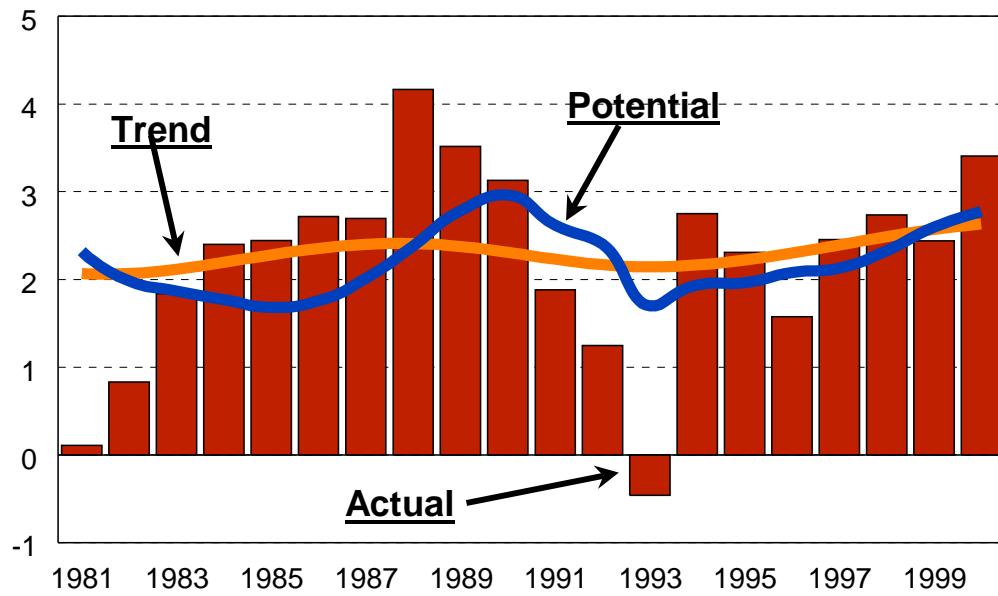
In this formulation $AGEK_0$ can be estimated as an additional parameter. Notice also that for large samples, the expression $(1-d)^t / K_t$ goes to zero. This means, in large samples β can be estimated consistently even if one ignores the last term. This is intuitively plausible, since any error one makes in calculating an initial value for the age of capital disappears as the sample grows larger.

ANNEX 3 : COMPARISON OF THE PRODUCTION FUNCTION AND HP FILTERED METHODS IN TERMS OF BOTH GDP LEVELS AND GDP GROWTH RATES

It is difficult to see why the HP filter method should produce a smoother series for both the trend growth and the output gap series. This difficulty is probably related to a confusion between levels and growth rates. The series of graphs given below hopefully helps to clarify this situation by showing the level and growth rate of actual, trend and potential GDP as well as the respective output gaps for the EU.



EU15 : Potential (PF), Trend (HP Filter)
and Actual GDP Growth Rates



**ANNEX 4 : POTENTIAL OUTPUT ESTIMATES
FOR THE EU'S MEMBER STATES**

TABLE 1 : POTENTIAL OUTPUT GROWTH RATES (PERIOD AVERAGES)**- COMPARISON OF ESTIMATES PRODUCED USING BOTH THE PRODUCTION FUNCTION (VINTAGE TFP METHOD) AND HP FILTER APPROACHES* -**

	1966-1970		1971-1980		1981-1990		1991-1995		1996-2000**	
	Prod. Function	HP Filter	Prod. Function	HP Filter	Prod. Function	HP Filter	Prod. Function	HP Filter	Prod. Function	HP Filter
Belgium	4.3	4.7	3.4	3.2	1.8	2.0	2.6	2.1	2.7 (3.0)	2.6 (2.8)
Denmark	3.3	3.9	2.3	2.2	1.7	1.6	1.7	1.9	2.5 (2.6)	2.4 (2.4)
Germany	3.9	4.1	2.7	2.6	2.1	2.3	2.7	2.3	2.1 (2.3)	2.0 (2.1)
Greece	8.5	8.0	4.4	4.4	0.7	1.0	2.2	1.7	2.9 (3.9)	3.0 (3.4)
Spain	5.9	6.5	3.7	3.5	2.4	2.5	2.6	2.7	2.7 (2.9)	3.2 (3.4)
France	4.9	5.1	3.5	3.4	2.1	2.2	1.9	1.9	1.9 (2.3)	2.3 (2.5)
Ireland	4.6	4.5	4.9	4.4	3.1	3.5	5.8	5.9	8.4 (8.5)	8.1 (8.3)
Italy	4.9	5.0	3.6	3.6	2.3	2.3	1.5	1.7	1.7 (2.3)	1.9 (2.1)
Luxembourg	2.3	3.7	3.3	2.5	3.8	4.3	5.8	5.8	6.2 (6.6)	5.8 (5.9)
Netherlands	5.6	5.0	3.0	3.0	2.0	2.1	2.6	2.9	3.5 (3.8)	3.4 (3.6)
Austria	3.7	4.9	4.1	3.5	1.9	2.3	2.8	2.4	2.4 (2.6)	2.5 (2.6)
Portugal	N.A.	N.A.	5.1	4.3	3.1	3.1	2.1	3.0	3.1 (3.5)	2.9 (2.9)
Finland	4.1	4.6	4.1	3.6	2.7	2.4	-0.1	1.7	4.4 (4.8)	3.6 (4.0)
Sweden	3.5	3.8	2.5	2.2	1.4	1.6	1.5	1.4	2.6 (3.1)	2.5 (2.9)
UK	2.4	2.8	2.2	2.0	2.2	2.3	2.2	2.3	2.7 (2.7)	2.6 (2.7)
EU15***	4.4	4.5	3.1	2.9	2.2	2.3	2.1	2.2	2.4 (2.7)	2.5 (2.6)
US	3.4	4.0	3.1	3.0	3.1	3.0	2.6	3.2	3.9 (4.4)	3.7 (3.6)

* IT IS MORE ACCURATE TO DESCRIBE THE GROWTH RATES PRODUCED BY THE HP FILTER APPROACH AS TREND AS OPPOSED TO POTENTIAL GROWTH RATES.

** PERIOD AVERAGE FOR 1998-2002 IN BRACKETS WITH THE COMMISSION SERVICES AUTUMN 2000 FORECASTS USED FOR THE FORECAST YEARS 2001 AND 2002.

*** CALCULATED USING EU15 AGGREGATED SERIES RATHER THAN AS A WEIGHTED AVERAGE OF THE 15 COUNTRIES. AN AGGREGATION BIAS IS NOT EVIDENT SINCE THE WEIGHTED AVERAGE FIGURES WERE ALSO CALCULATED AND THE FIGURES WERE EITHER IDENTICAL TO, OR WERE NO MORE THAN +/- 0.1 COMPARED WITH, THE FIGURES PRODUCED USING THE AGGREGATED SERIES.

**** FOR THE PERIOD 1966-1980 THE HP-FILTERED UNEMPLOYMENT RATE IS USED AS A PROXY FOR THE NAIRU.

TABLE 1A : POTENTIAL OUTPUT GROWTH RATES
CONTRIBUTIONS TO GROWTH FROM EMPLOYMENT, CAPITAL STOCK AND TFP (PERIOD AVERAGES)

	1966-2000				1966-1970			
	Potential Growth*	Contributions to Growth			Potential Growth	Contributions to Growth		
		Labour**	Capital	TFP		Labour**	Capital	TFP
Belgium	2.8 (2.8)	0.2	1.0	1.6	4.3	0.3	1.4	2.6
Denmark	2.2 (2.3)	0.3	0.8	1.1	3.3	0.6	1.6	1.1
Germany	2.6 (2.6)	0.2	1.0	1.4	3.9	-0.1	1.6	2.4
Greece	3.4 (3.3)	0.4	1.6	1.4	8.5	-0.2	2.7	6.0
Spain	3.4 (3.5)	0.2	1.4	1.8	5.9	0.4	2.0	3.5
France	2.9 (2.9)	0.3	1.1	1.5	4.9	0.5	1.7	2.7
Ireland	4.9 (4.9)	0.7	1.4	2.8	4.6	-0.2	1.7	3.1
Italy	2.8 (2.9)	0.3	1.0	1.5	4.9	0.2	1.7	3.0
Luxembourg	4.1 (4.1)	1.2	0.9	2.0	2.3	0.5	0.0	1.8
Netherlands	3.1 (3.1)	0.8	1.0	1.3	5.6	0.7	2.0	2.9
Austria	3.0 (3.0)	0.2	1.2	1.6	3.7	-0.1	1.3	2.5
Portugal	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.
Finland	3.1 (3.1)	0.0	1.0	2.1	4.1	0.1	1.6	2.4
Sweden	2.2 (2.2)	0.2	0.8	1.2	3.5	0.7	1.4	1.4
UK***	2.3 (2.3)	0.2	0.7	1.4	2.4	-0.1	1.1	1.4
EU15****	2.8 (2.8)	0.2	1.0	1.6	4.4	0.1	1.6	2.7
US	3.2 (3.3)	1.2	1.0	1.0	3.4	1.3	1.2	0.9

* HP FILTER AVERAGE FOR 1966-2000 IS IN BRACKETS.

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TABLE 1B : POTENTIAL OUTPUT GROWTH RATES
CONTRIBUTIONS TO GROWTH FROM EMPLOYMENT, CAPITAL STOCK AND TFP (PERIOD AVERAGES)

	1971-1980				1981-1990			
	Potential Growth	Contributions to Growth			Potential Growth	Contributions to Growth		
		Labour*	Capital	TFP		Labour	Capital	TFP
Belgium	3.4	-0.1	1.3	2.2	1.8	0.2	0.7	0.9
Denmark	2.3	0.2	1.1	1.0	1.7	0.4	0.5	0.8
Germany	2.7	0.0	1.2	1.5	2.1	0.4	0.7	1.0
Greece	4.4	0.3	2.3	1.8	0.7	0.7	1.1	-1.1
Spain	3.7	-0.4	1.8	2.3	2.4	0.2	1.0	1.2
France	3.5	0.3	1.4	1.8	2.1	0.2	0.9	1.0
Ireland	4.9	0.6	1.9	2.4	3.1	-0.2	1.1	2.2
Italy	3.6	0.5	1.3	1.8	2.3	0.4	0.9	1.0
Luxembourg	3.3	0.7	0.7	1.9	3.8	1.0	0.8	2.0
Netherlands	3.0	0.4	1.3	1.3	2.0	0.7	0.6	0.7
Austria	4.1	0.2	1.5	2.4	1.9	0.2	1.0	0.7
Portugal	5.1	0.7	1.8	2.6	3.1	0.4	1.4	1.3
Finland	4.1	0.5	1.4	2.2	2.7	-0.2	1.0	1.9
Sweden	2.5	0.5	1.0	1.0	1.4	0.0	0.7	0.7
UK**	2.2	0.0	0.8	1.4	2.2	0.2	0.6	1.4
EU15***	3.1	0.2	1.3	1.6	2.2	0.3	0.8	1.1
US	3.1	1.3	1.1	0.7	3.1	1.2	0.9	1.0

* FOR THE PERIOD 1966-1980 THE HP-FILTERED UNEMPLOYMENT RATE IS USED AS A PROXY FOR THE NAIRU.

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TABLE 1C : POTENTIAL OUTPUT GROWTH RATES
CONTRIBUTIONS TO GROWTH FROM EMPLOYMENT, CAPITAL STOCK AND TFP (PERIOD AVERAGES)

	1991-1995				1996-2000			
	Potential Growth	Contributions to Growth			Potential Growth	Contributions to Growth		
		Labour	Capital	TFP		Labour	Capital	TFP
Belgium	2.6	0.3	0.8	1.5	2.7	0.5	0.8	1.4
Denmark	1.7	0.1	0.3	1.3	2.5	0.2	0.6	1.7
Germany	2.7	0.2	0.9	1.6	2.1	0.0	0.7	1.4
Greece	2.2	0.6	0.9	0.7	2.9	0.4	1.0	1.5
Spain	2.6	0.9	1.2	0.5	2.7	0.9	1.2	0.6
France	1.9	0.2	0.8	0.9	1.9	0.3	0.7	0.9
Ireland	5.8	1.5	0.8	3.5	8.4	2.7	1.6	4.1
Italy	1.5	0.1	0.6	0.8	1.7	0.2	0.6	0.9
Luxembourg	5.8	2.0	1.6	2.2	6.2	2.4	1.6	2.2
Netherlands	2.6	1.2	0.6	0.8	3.5	1.4	0.8	1.3
Austria	2.8	0.4	1.1	1.3	2.4	0.3	1.0	1.1
Portugal	2.1	0.4	1.0	0.7	3.1	0.5	1.3	1.3
Finland	-0.1	-1.7	-0.1	1.7	4.4	0.7	0.2	3.5
Sweden	1.5	-0.3	0.2	1.6	2.6	0.2	0.3	2.1
UK*	2.2	0.3	0.5	1.4	2.7	0.5	0.8	1.4
EU15**	2.1	0.3	0.7	1.1	2.4	0.4	0.7	1.3
US	2.6	1.0	0.7	0.9	3.9	1.0	1.2	1.7

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